Fire regimes and forest structure of Utah and eastern Nevada: A multi-scale history from tree rings

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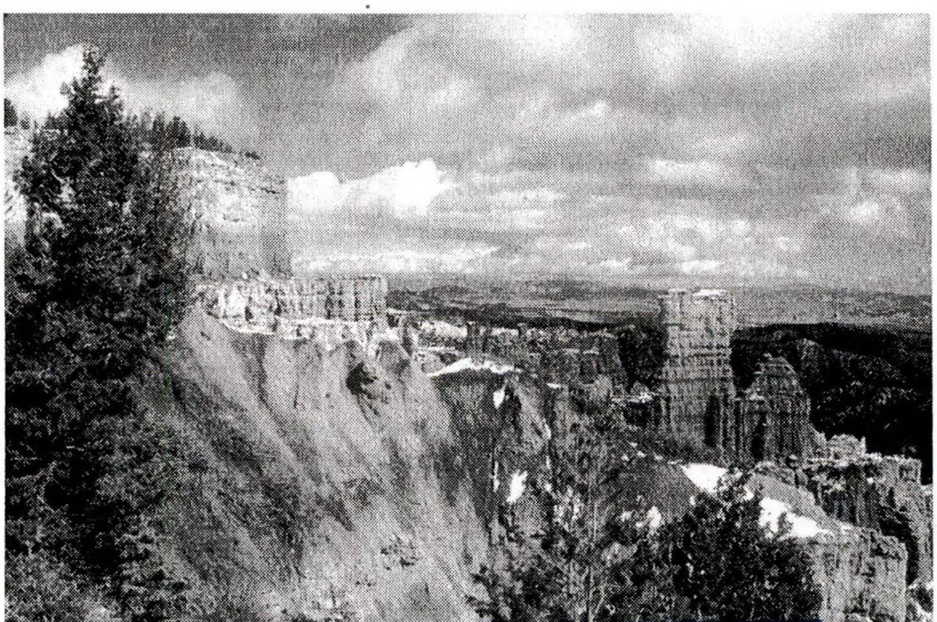

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INTRODUCTION

Twentieth century fire exclusion has profoundly changed forest structure across the interior of western North America (e.g., Covington et al. 1997, Swetnam et al. 1999). However, fire exclusion has not affected all forests uniformly because fire regimes, and their effects on forest structure, were not uniform across landscapes. Rather, fire regimes varied both across landscapes and through time in response to factors such as topography, forest type, climate and changes in land use. While we understand the influence of some of these factors on current fires regimes, we do not fully understand their influence on historical fire regimes. Consequently, we cannot accurately estimate historical fire regimes in one area by extrapolating from other areas. For example, fires in the same plant association were historically more frequent in the southern than the northern Blue Mountains in Oregon because there is a gradient in precipitation across that region, a finding that surprised local forest managers (Heyerdahl et al. 2001). Furthermore, the *effects* of historical fires and fire exclusion on forest structure also vary across the landscape. For example, fire exclusion has resulted in greater changes in ponderosa pine (*Pinus ponderosa* Laws. var. *scopulorum* Engelm.) forests that sustained frequent surface fires than in either high-elevation mixed-conifer forests, that sustained infrequent mixed-severity fires, or low-elevation pinyon-juniper forests that sustained infrequent moderate to high severity fires (Veblen 2000). Consequently, local fire and forest histories are needed to provide critical physical evidence of change and to assess the need for management of these forests, including fuel treatment, wildland fire use and/or prescribed fire. Understanding the departure of current forests from historical conditions can also provide justification for management plans for specific forests, to land management agencies and the public. However, only by understanding the drivers of fire regimes through time and space can we predict how such local fire and forest histories can be extrapolated across broader regions.

Our objective was to reconstruct spatially explicit histories of fire and forest structure across landscape-scale gradients in forest types and topography at 14 sites in Utah and 1 in eastern Nevada (Figure 1). In addition, we reconstructed a history of surface fires from one plot on Old Woman Plateau (OWP), 5 plots at Ray Mesa (RAY) and crossdated samples collected in a previous study on Monroe Mountain (MON). These sites include 4 that are in the jurisdiction of the Bureau of Land Management.

STUDY AREA

The sites we selected for this study extend from the Colorado plateau area of southern Utah, west to the Wah Wah Mountains and Snake Range in the eastern Great Basin, to the Bear River Range in northern Utah (Figure 1). The area is a complex of valleys, mesas, canyons, plateaus, and mountains that range in elevation from under 3000 ft to over 12,000 ft. We choose study sites to include the range of forested vegetation across the region, which varies greatly, often forming spatially complex mosaics. General patterns in vegetation vary strongly across elevational gradients. Arid lowlands are dominated by desert scrub or grasslands that extend up to cooler and moister alpine vegetation above treeline. Sagebrush (*Artemisia sp.*) and shrub communities are found from low to mid-elevations, either in uniform stands or in association with conifer woodlands at the upper limits of their distribution. Pinyon (*Pinus edulis* Engelm. on the Colorado Plateau and (*P. monophylla* Torr.& Frem. in the Great Basin) and Rocky Mountain and Utah juniper (*Juniperus scopulorum* Sarg. and *J. osteosperma* (Torr.) Little, respectively) woodlands occur on dry-mountain slopes, mesas, and plateaus between desert shrub/grasslands

and montane forests. Ponderosa pine forests occur in montane zones, either in pure stands or intermixed with species that dominate at both higher and lower elevations. Douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franco var. *glauca* (Beissn.) Franco) also occurs in these areas but is more often found on north aspects. Mixed-conifer forests occur at intermediate elevations between ponderosa pine forests and subalpine forests, and can include numerous conifer species including ponderosa pine, Douglas-fir, pinyon, juniper, true firs (*Abies lasiocarpa* (Hook) Nutt. and *A. concolor* (Gord. & Glend.) Lindl.ex Hildebr.), or lodgepole pine (*Pinus contorta* Dougl. ex Loudon), often in association quaking aspen (*Populus tremuloides* Michx.). In the Uintah Mountains and the Wasatch Range at the northern end of the study area, lodgepole pine often forms pure stands at high elevations, above mixed-conifer stands. Spruce (*Picea engelmannii* Parry ex Engelm.)-fir (*Abies* sp.) forests occur at upper elevations (7800-11,000 ft) in the sub-alpine zone across the region. At the highest forested elevations (generally above 10,000 feet), pure spruce stands occur in mesic sites and high-elevation conifers (Great Basin bristlecone pine [*Pinus longaeva* D.K. Bailey] or limber pine [*Pinus flexilis* James]) are often found in dry or rocky sites.

Early Euro-American land-use within the study area included trappers and traders representing several fur companies from about 1800 to 1840. Some caravan travel to Nevada and California occurred in the 1830s and 1840s. Mormon converts first settled the Great Salt Lake Valley in 1847. Numerous satellite settlements were established throughout most of the study area by the end of the 1860s, with settlement in more remote areas 10 to 15 years later. The settlement and livestock husbandry practices of these early settlers were unique in the western United States (Young et al. 1979). Small groups of settlers were sent by their leader, Brigham Young, to establish agriculture-based communities wherever water, forage, and timber resources could be found to sustain them. Most of these original settlers owned only a few cows, horses, or sheep. Efficient herding was accomplished by uniting livestock into community herds during the day and returning animals to the safety of the community at night. Subsequently, forage resources close to the communities were often degraded and those at some distance used lightly, if at all. Although livestock numbers and the incidence of private herds increased steadily after settlement, this general pattern of livestock dispersal persisted until after the end of the Black Hawk War in the late 1860s (Nielson 1953). After this time, significant expansion of livestock into mountain pastures occurred. When railroad service expanded in the late 1880s, livestock numbers, especially sheep, increased dramatically. Locally owned herds competed with those brought in by outside interests. By 1890 forage on the mountains and high plateaus of Utah and eastern Nevada was severely depleted. Late nineteen and early twentieth century mining activities in the Wasatch Mountains and numerous central and southern Utah locations created additional impacts on forage and timber resources on a local scale.

METHODS

Sampling design for gridded sites

We sampled 13 complete gridded sites and two partial gridded sites (UFR and INC, Table 1, Figure 1). We sampled a total of 404 plots over 20,926 acres (323 to 2248 acres per site) on grids with a 0.3 mile (500 m) spacing between plots. At each plot, we measured slope, aspect, elevation and location. We took four photographs, one in each cardinal direction, and estimated ground cover (as percentage of rock, litter, bare ground, forbs, grasses and shrubs). To compute an index of soil moisture (Parker 1982), we also classified each plot by topographic position

(valley bottom, lower slope, middle slope, upper slope or ridge top) and slope shape (concave, straight or convex). We assigned each plot to a category of historical (1860) and modern vegetation (2000), according to vegetation classifications developed for LANDFIRE (biophysical setting (BpS) and existing vegetation (EVT), respectively; Table 2, www.landfire.gov). The BpS category indicates the vegetation that can potentially exist at a given site based on both the biophysical environment and an approximation of the historical fire regime. It is similar in concept to the potential natural vegetation groups used in developing fire regime condition classes (Schmidt et al. 2002). BpS was formerly referred to as potential natural vegetation groups and are derived from NatureServe (a non-profit conservation organization that provides scientific information and tools) Ecological System Classification models (Comer et al. 2003).

Topography at gridded sites

To evaluate whether the topography of the plots we sampled at a site is representative of the sampling areas as a whole at that site, we compared the distribution of plots among three topographic parameters (elevation, slope and aspect) to that of land area in the sampling grid. The topographic parameters for the study area were derived from digital elevation models (30 m resolution; Utah AGRC 2004).

Tree recruitment at gridded sites

To reconstruct the history of tree recruitment at each plot, we used an n-tree density-adapted sampling method (Jonsson et al. 1992, Lessard et al. 2002). We sampled all trees (whether living or dead) >8 inches in diameter at breast height (DBH, 4.5 feet) that were closest to plot center, up to a maximum of 34 trees (average 29 trees per plot). Plot size varied with tree density (0.03 to 3.09 acres; average 0.39 acres), and was computed as the area of a circle with radius equal to the distance between plot center and the farthest tree sampled (range 20 to 207 feet, average 74 feet). For each trees in a plot, we determined species, DBH, and diameter at sampling height. From live trees, we removed increment cores ≈8 inches above the ground. From dead trees that were sound enough to crossdate, we used a chain saw to remove a section, including the pith, from what would have been ≈8 inches above the ground. We did not remove a section from dead trees that were not sound enough to crossdate, but tallied them instead. All cores and sections were sanded until the cell structure was visible with a binocular microscope. We assigned calendar years to tree rings using a combination of visual crossdating of ring widths and cross-correlation of measured ring-width series (Holmes 1983), using existing master ring-width chronologies and some that we developed ourselves. We estimated the recruitment date of each tree as its pith date at sampling height. Most increment cores (71%) did not intersect the pith. To estimate the pith date of these trees, we estimated the number of years to pith from the curvature of the innermost rings sampled (average years to pith: 8; Applequist 1958, Duncan 1989) and subtracted this estimate from the innermost ring date. Some samples could not be crossdated and were excluded from subsequent analyses.

We computed the change in forest structure and composition through time as the density of trees >8 inches DBH at each plot, pooled by forest type within each site, in 1860 and in 2000. To compute the density in 1860, we included all dated trees that were alive in that year, plus eroded logs and stumps (i.e., trees from which the outside rings had been removed by rot or fire) if their outside rings post-dated 1800, and their inside ring dates predated 1860.

Surface fires at gridded sites

To reconstruct a history of surface fires, we searched for fire-scarred trees within a radius of ≈260 feet of each plot center (corresponding to an area of ≈5 acres), and used a chain saw to remove one to several scarred sections per tree (662 trees, Arno and Sneck 1977). We removed sections from an additional 373 fire-scarred trees that we encountered between plots. We sanded and crossdated all samples as described above for recruitment-date samples.

We identified the calendar year in which each scar formed, to determine the year of fire occurrence, and the position of each scar within the ring (ring boundary, early-earlywood, middle-earlywood, late-earlywood, latewood or unknown), as an indication of the season of fire occurrence (Dieterich and Swetnam 1984). In addition to fire scars, we obtained a small amount of supporting evidence of surface fires (15% of fire records) from eroded fire scars (ones for which much or all of the overlapping, curled rings were destroyed by subsequent fires or rot) and abrupt changes in the width of annual rings. However, because factors other than surface fires can cause abrupt changes in cambial growth, we used such a change in a given sample as evidence of a surface fire only when it was synchronous with, or followed within 2 years of, a fire scar in other samples at the same site. In the northern hemisphere, the season of cambial dormancy (i.e., the period corresponding to the ring boundary) spans two calendar years: from the time the cambium stops growing in the fall of one year until it resumes in the spring of the following year. For most of the southern sites in this study, we assigned ring-boundary scars to the *following* calendar year because most modern fires in southern Utah burn early in the cambial growing season (Barrows 1978, Swetnam 1990, Kitchen and McArthur 2003). In contrast, for the remaining sites in the north (WCH, WUN, MUR, BRO and BCL), we assigned ring-boundary scars to the *preceding* calendar year, because most modern fires in northern Utah burn late in the cambial growing season. Occasionally however, some late (early) season fires occur in southern (northern) Utah and scars from a given fire can have a range of intra-annual positions because the timing of radial growth varies across the landscape (Fritts 1976). Therefore, when a fire year at a southern (northern) site had many ring-boundary scars and some late- (early-) season scars, we assigned all the scars from that fire year to the following (preceding) year (only 5% of total scar dates changed). We were unable to determine the intra-ring position of some scars (28%) because they were obscured by rot or insect galleries, or the rings were narrow.

Fire frequency at gridded sites

To compute fire frequency, we divided each site into cells (Thiessen polygons) of roughly equal area centered on our plots, and composited the fire dates from all trees sampled within a cell into a single fire chronology for that cell (Dieterich 1980). Most cells (95%) include between 56 and 73 acres (range: 32 to 86 acres). We determined the number of years that fire was recorded on at least one tree within each *cell,* but also limited our analysis to fire dates recorded on at least two trees within a *site* to minimize the inclusion of scars that might appear to have been created by fire but were actually created by other processes, such as lightning or frost. We assumed that these non-fire processes are unlikely to scar more than one tree in a given year at a site. We report the number of fires in cell-composites for an analysis period from 1650 to 1900, compared to the elevation and forest types (Table 2) for the plot at the center of each cell. If no fire-scarred trees were collected or dated in a cell, we inferred the number of fires from the recruitment date of the oldest tree collected in the plot at the center of that cell. We inferred a single fire if the recruitment date was within the analysis period (1650-1900), or no fires if the recruitment date was outside the analysis period.

Non-gridded sites

At Old Woman Plateau (OWP), we used a targeted sampling design to reconstruct a history of surface fires. The forest at this site is mainly old-growth ponderosa pine and we searched a portion of the mesa top for trees with multiple fire scars. The mesa is relatively flat and bounded by steep canyons and cliffs to the east, north and south. We removed partial cross sections from 17 ponderosa pine stumps, snags and logs over an area of 49 acres, and sanded and crossdated them as described for the gridded sites. Samples from one tree could not be crossdated and were excluded from further analyses. We composited the record from all trees into a single record of fire for this site, and computed fire intervals for the same analysis period as the gridded sites (1650-1900).

At Ray Mesa (RAY), we sampled 5 stands to capture a range in forest-type variation. The vegetation is mainly pinyon-juniper woodlands and forests, and sagebrush meadows, with stands of ponderosa pine localized mainly in drainages or rocky areas on the mesa top. We sampled trees and determined recruitment dates as described above for plots at the gridded sites. We searched for fire-scarred trees within ≈260 feet of each plot center. We also collected fire-scarred trees from an additional stand of ponderosa pine located ~2 km NE of the initial transect to examine possible spatial patterns of fires across the mesa top.

In a previous study (Chappell 1997), fire-scarred and recruitment-date sections were removed from ≈40 trees at ≈16 locations on Monroe Mountain. Of these, we crossdated fire-scarred sections from 12 trees (8 ponderosa pine, 2 Douglas-fir, 1 quaking aspen and 1 two-needle pinyon. We did not composite fire dates across this site because the location of the sampled trees is not known, nor is the total size of the sampled area.

Figures and tables for methods section

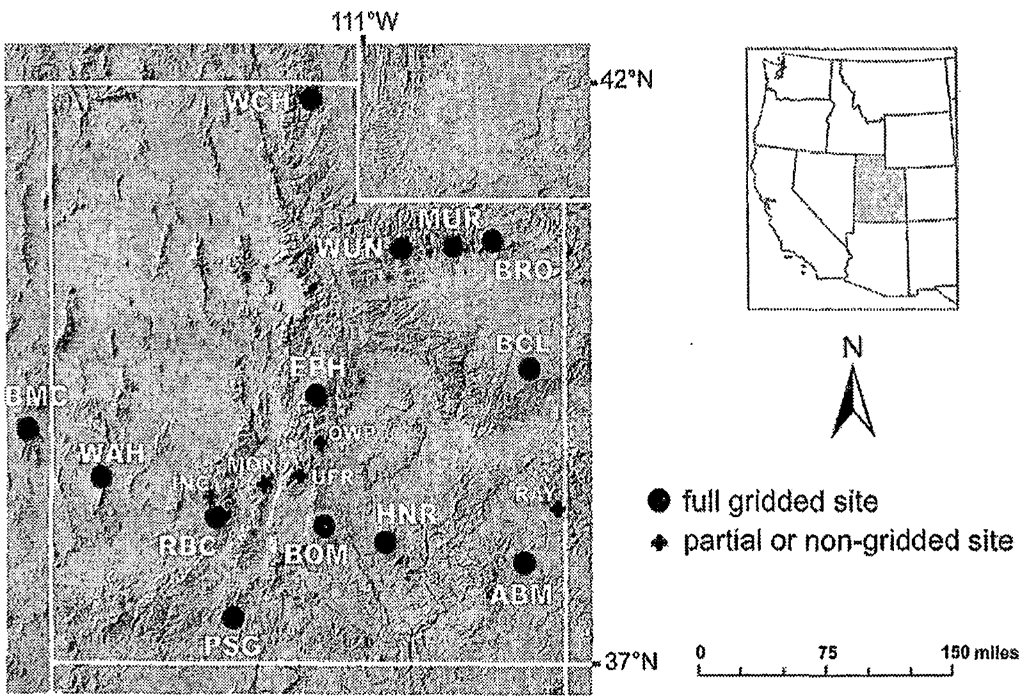


Figure 1. Location of fire and forest history sampling sites in Utah (shaded state in inset map) and eastern Nevada.

Table 1. Amount of evidence used to reconstruct fire and forest histories in Utah and eastern Nevada (9108 total dated recruitment dates and 1064 dated fire-scarred trees). Fire-scarred trees at MON were collected for a previous study (Chappell 1997).

	sampling	No. plots	trees in plots		fire-scarred trees	
Site code	area (ac)	sampled	No. trees	dated	No. trees	dated
Gridded sites						
ABM	1572	28	754	96%	81	90%
BCL	1303	29	883	83%	32	79%
BMC	1130	24	674	85%	128	86%
BOM	1226	30	892	92%	132	91%
BRO	1325	30	841	98%	75	100%
EPH	1414	30	856	96%	38	82%
HNR	1742	30	868	84%	25	73%
INC	323	6	182	92%	38	97%
MUR	1441	30	810	81%	97	87%
PSG	1787	29	844	91%	73	75%
RBC	2248	44	1332	86%	195	86%
UFR	979	15	447	73%	25	76%
WAH	1064	24	730	88%	142	99%
WCH	1612	30	909	93%	18	89%
WUN	1760	25	745	85%	76	88%
TOTAL	20926	404	11767	88%	1175	88%
Non-gridded sites						
OWP	49	1	--	--	17	94%
MON	--	--	--	--	12	100%
RAY	328	5	--	--	20	100%

Table 2. Forest types assigned to plots, and the groups of biophysical settings of which they are composed.

forest type	biophysical setting	code
spruce-fir	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	1055
spruce-fir	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	1056
limber-bristlecone	Inter-Mountain Basins Subalpine Limber-Bristlecone Pine Woodland	1020
lodgepole	Rocky Mountain Lodgepole Pine Forest	1050
aspen	Rocky Mountain Aspen Forest and Woodland	1011
aspen-mixed conifer	Inter-Mountain Basins Aspen - Mixed Conifer Forest and Woodland	1061
mixed conifer	Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland	1051
mixed conifer	Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland	1052
ponderosa pine	Southern Rocky Mountain Ponderosa Pine Woodland	1054
ponderosa pine	Rocky Mountain Ponderosa Pine Savanna	1117
mountain mahogany	Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland	1062
pinyon-juniper	Colorado Plateau Pinyon-Juniper Shrubland	1102
pinyon-juniper	Colorado Plateau Pinyon-Juniper Woodland	1016
pinyon-juniper	Great Basin Pinyon-Juniper Woodland	1019
oak	Rocky Mountain Gambel Oak - Mixed Montane Shrubland	1107
sagebrush	Inter-Mountain Basins Montane Sagebrush Steppe	1126
shrubland	Rocky Mountain Lower Montane-Foothill Shrubland	1086

WAH WAH MOUNTAINS - BUREAU OF LAND MANAGEMENT (WAH)

Study Area

We sampled a grid of 24 plots over 1064 acres near Lawson Cove Canyon, on the Richfield District, Bureau of Land Management, in Millard county, Utah (Figure 2). The plots ranged in elevation from 7200 to 8810 feet, and in slope from 12 to 58%. The plots were sampled on a range of aspects, although most plots were on north or east aspects (83%, Figure 3). The topography of the plots we sampled was generally similar to that of the sampling area at this site.

Results

Tree recruitment

Our plots included 730 total trees (74% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 672 trees and were able to crossdate most of these (588 trees, or 88% of sampled trees). The trees that occurred on our plots included a range of species (Figure 4). Trees were recruited into the sampled plots between 588 and 1893, although most trees (80%) were recruited after 1610 (Figure 5).

Average tree density was higher at plots in 2000 than in 1860 for all 3 of the forest types that we assigned to the sampled plots at this site (pinyon-juniper, mixed conifer and limber-bristlecone, Figure 6, Table 2).

Surface fires

We removed fire-scarred sections from a total of 142 trees at WAH. We sampled more than half of these (57%) in the 20 of our 24 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were ponderosa pine (67%), white fir (10%) or Great Basin bristlecone pine (8%), but we also sampled a few fire-scarred singleleaf pinyon, Douglas-fir, Utah juniper and Rocky Mountain juniper. Most of the trees we sampled were logs, snags or stumps (66%), with the rest live trees. We were unable to crossdate sections from some of the sampled trees (1%). Those that we did crossdate yielded 375 fire scars, and 92 eroded fire scars or abrupt changes in ring width (1200 to 2003; Figure 7). We were able to assign an intra-ring position to 81% of the fire scars. Most of the scars from the analysis period (1650-1900) were created by fires burning early in the cambial growing season or when the cambium was dormant (84% of assigned scars, Figure 8).

There is a long history of frequent surface fires at WAH (Figure 7, Figure 9). During the analysis period (1650-1900), the number of surface fires during the analysis period (1650-1900) varied with elevation and forest type, although there are only 3 forest types at this site. Surface fires ceased in the early 1800s at this site.

Figures and tables for WAH

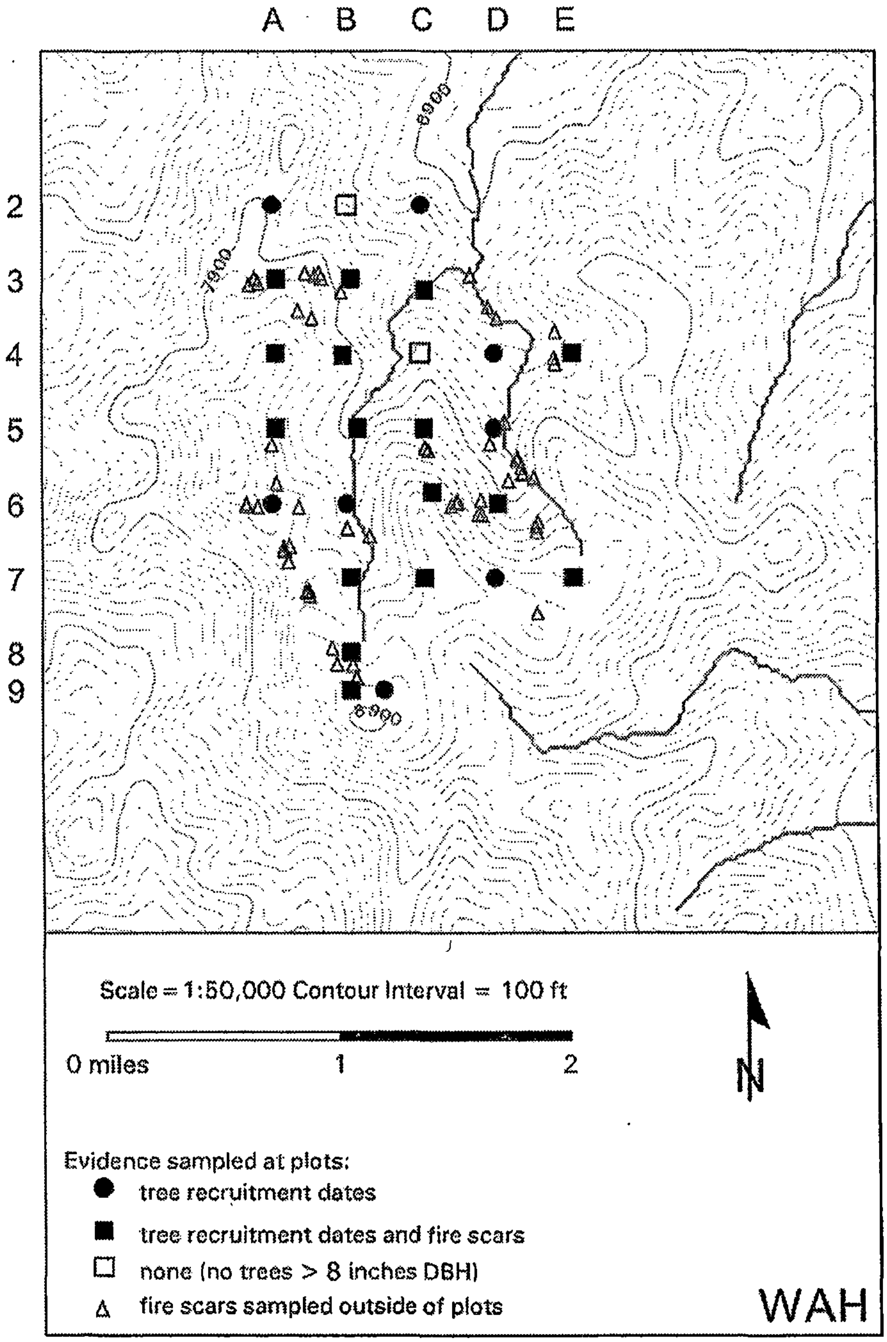


Figure 2. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the northwestern most plot is 2A, the next plot to the east is 2b, etc. Many of the fire-scarred trees (57% of 141 dated trees) were sampled within plots and so are not mapped individually. The plot in the 9 row, between columns B and C is plot 9X, and was sampled to replace what would have been plot 9C, which lay on a cliff. Plots 2B and 4C had trees >8 inches DBH, but were too hazardous to access and/or sample.

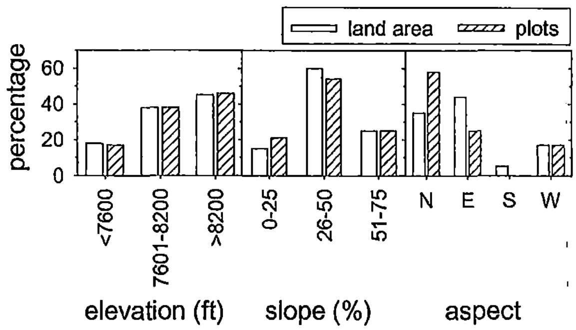


Figure 3. Distribution of topography for sampled plots and for land area at WAH. Aspect classes are 90° wide, beginning with 46° for east (E). Land area was derived from a digital elevation model.

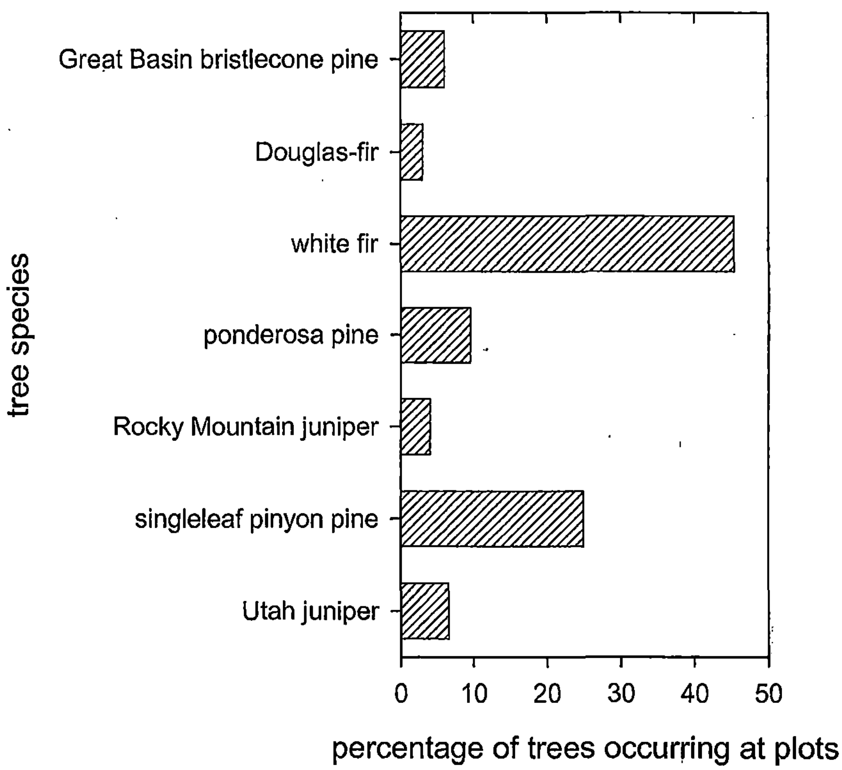


Figure 4. Species distribution of all trees that occurred in plots at WAH.

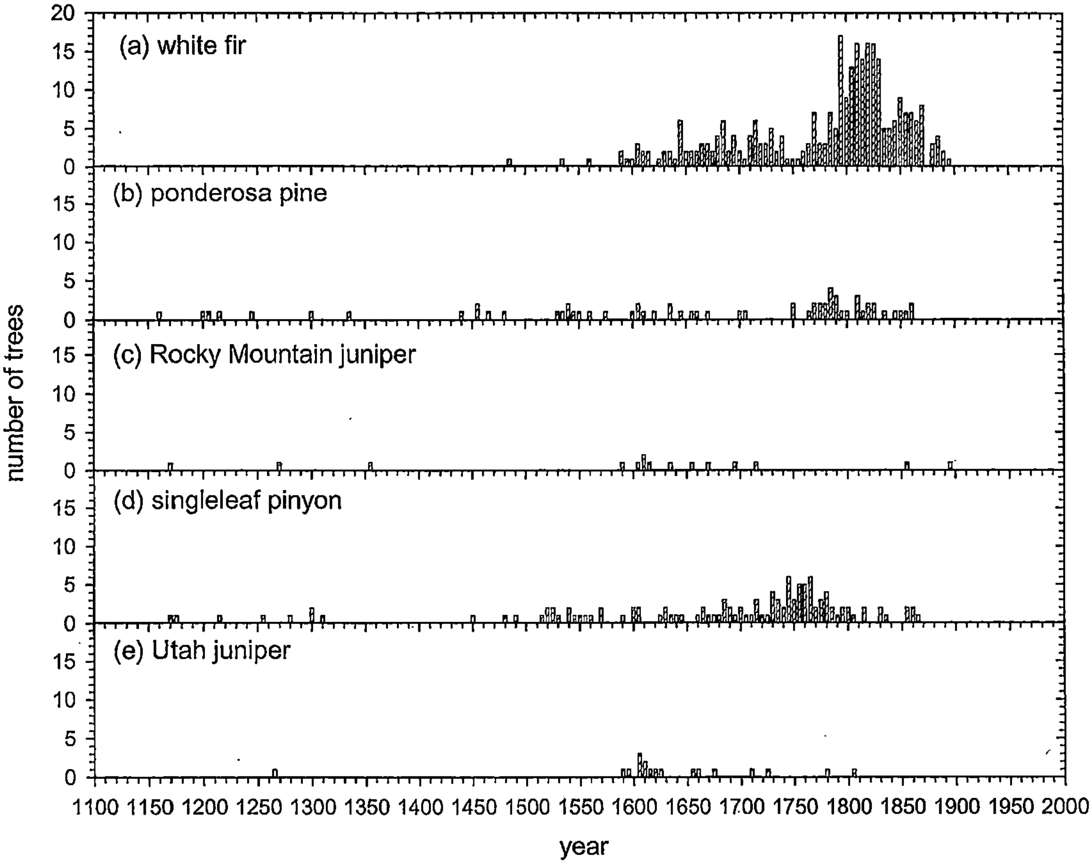


Figure 5. Distribution of tree-recruitment dates by species at WAH, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

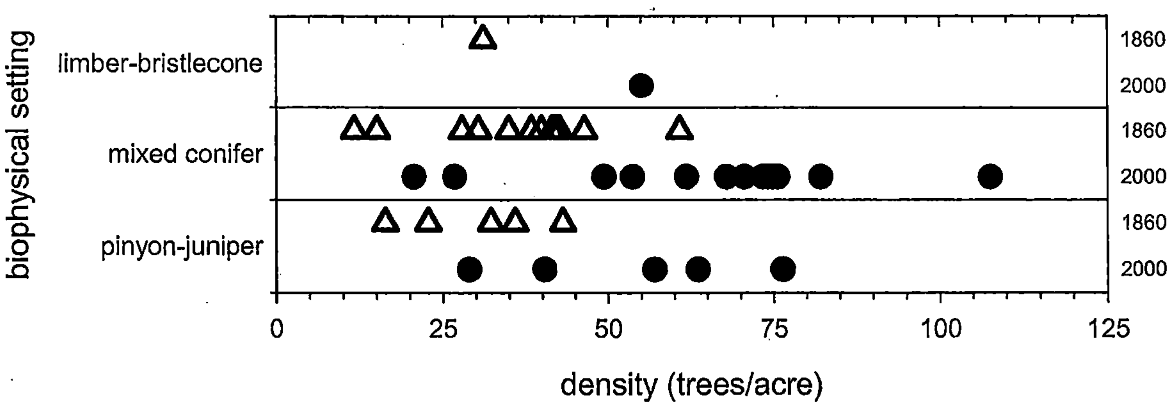


Figure 6. Density of live trees >8 inches DBH at each plot at WAH, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

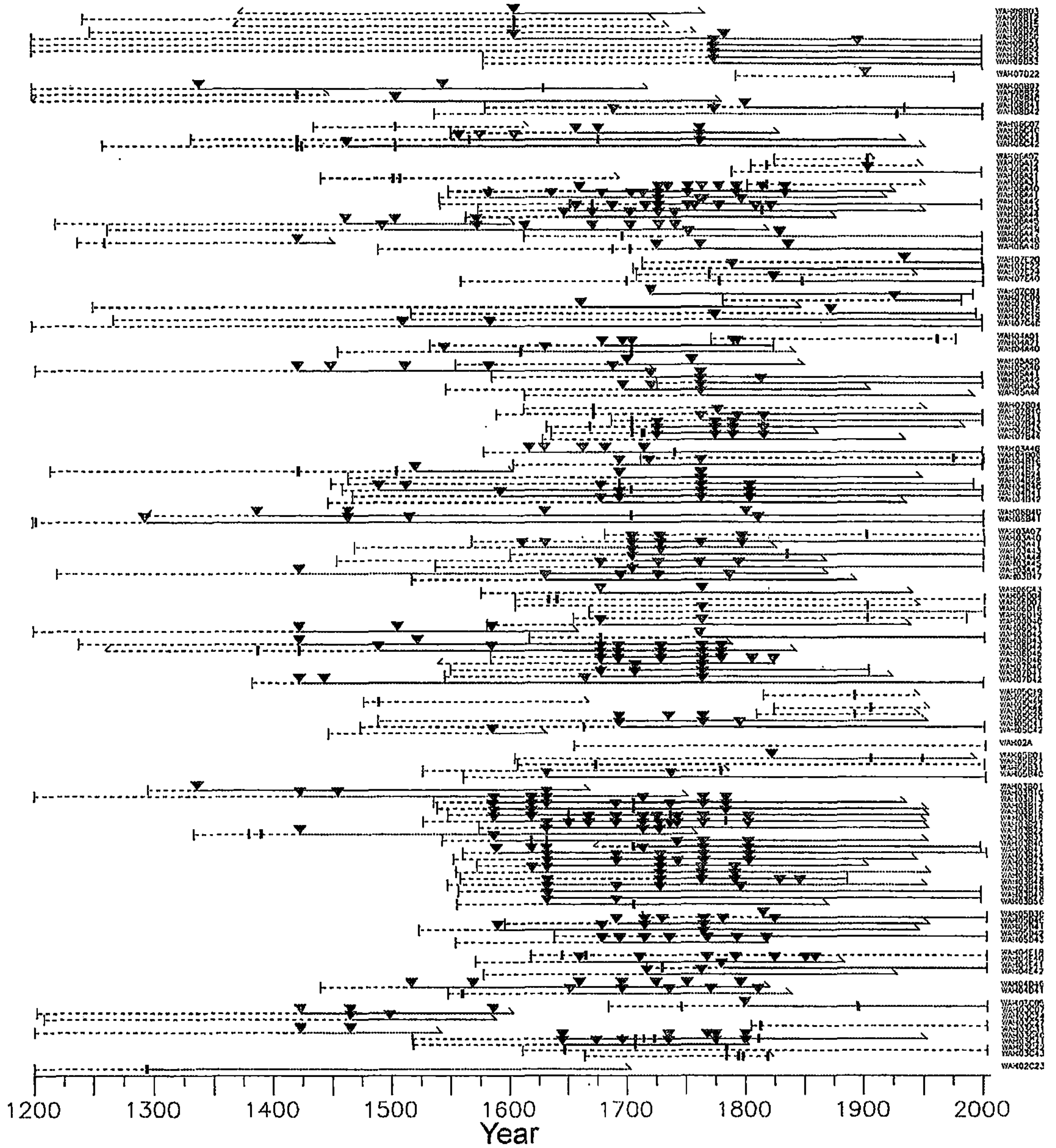


Figure 7. Fire chronologies at WAH, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

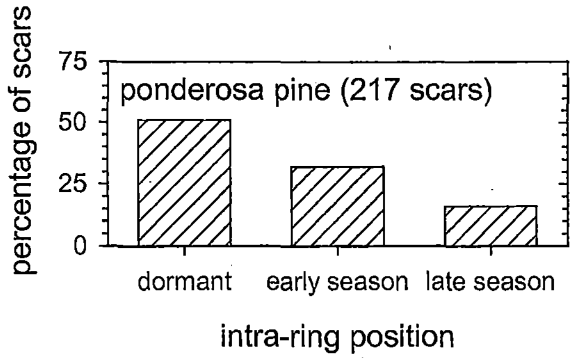


Figure 8. Intra-ring position of fire scars at WAH (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only species that comprised >10% of trees are plotted. We also dated scars from some Douglas-fir, white fir, Utah juniper, singleleaf pinyon, Great Basin bristlecone pine and Rocky Mountain juniper, but these species yielded too few scars with an intra-ring position to plot here.

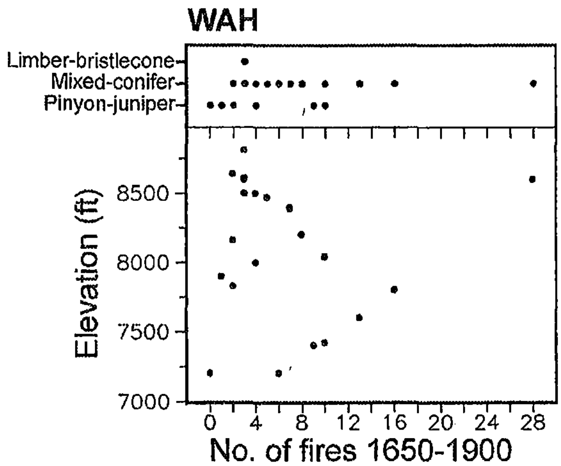
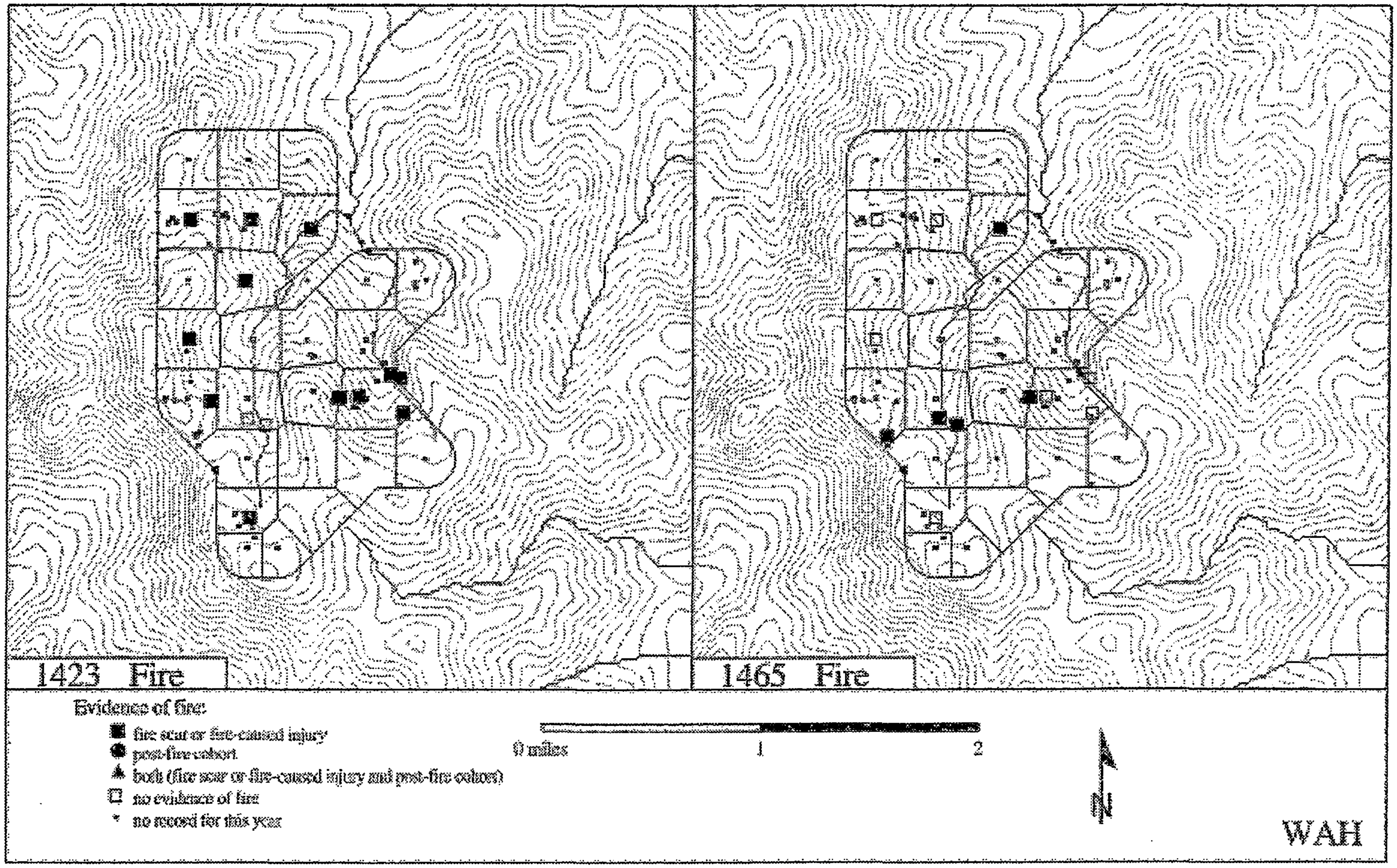


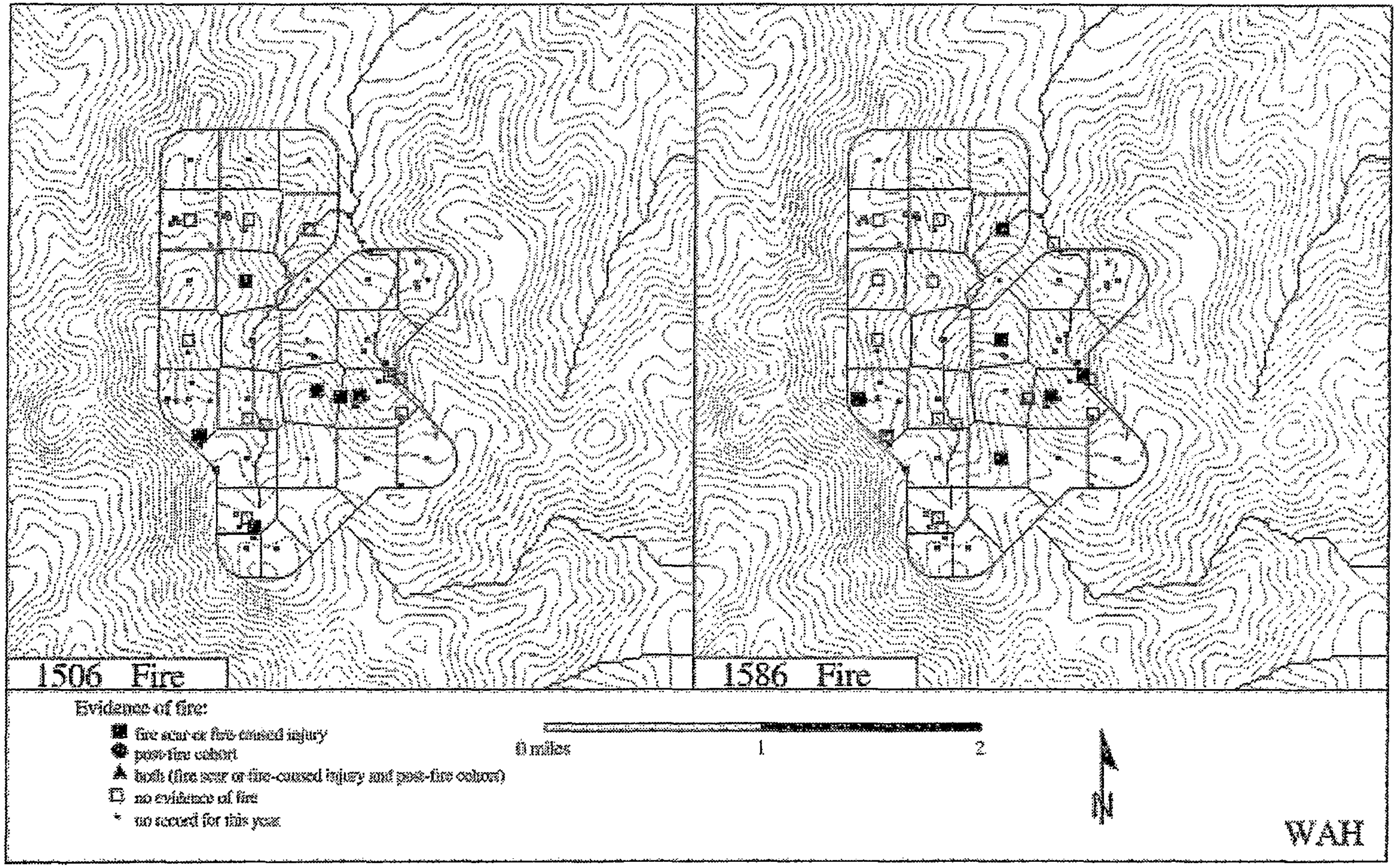
Figure 9. Number of fires within cells at WAH (1650-1900), by forest type (top panel, Table 2) and elevation (bottom panel). Number of fires includes only those fire years which were recorded on ≥2 trees at a site.

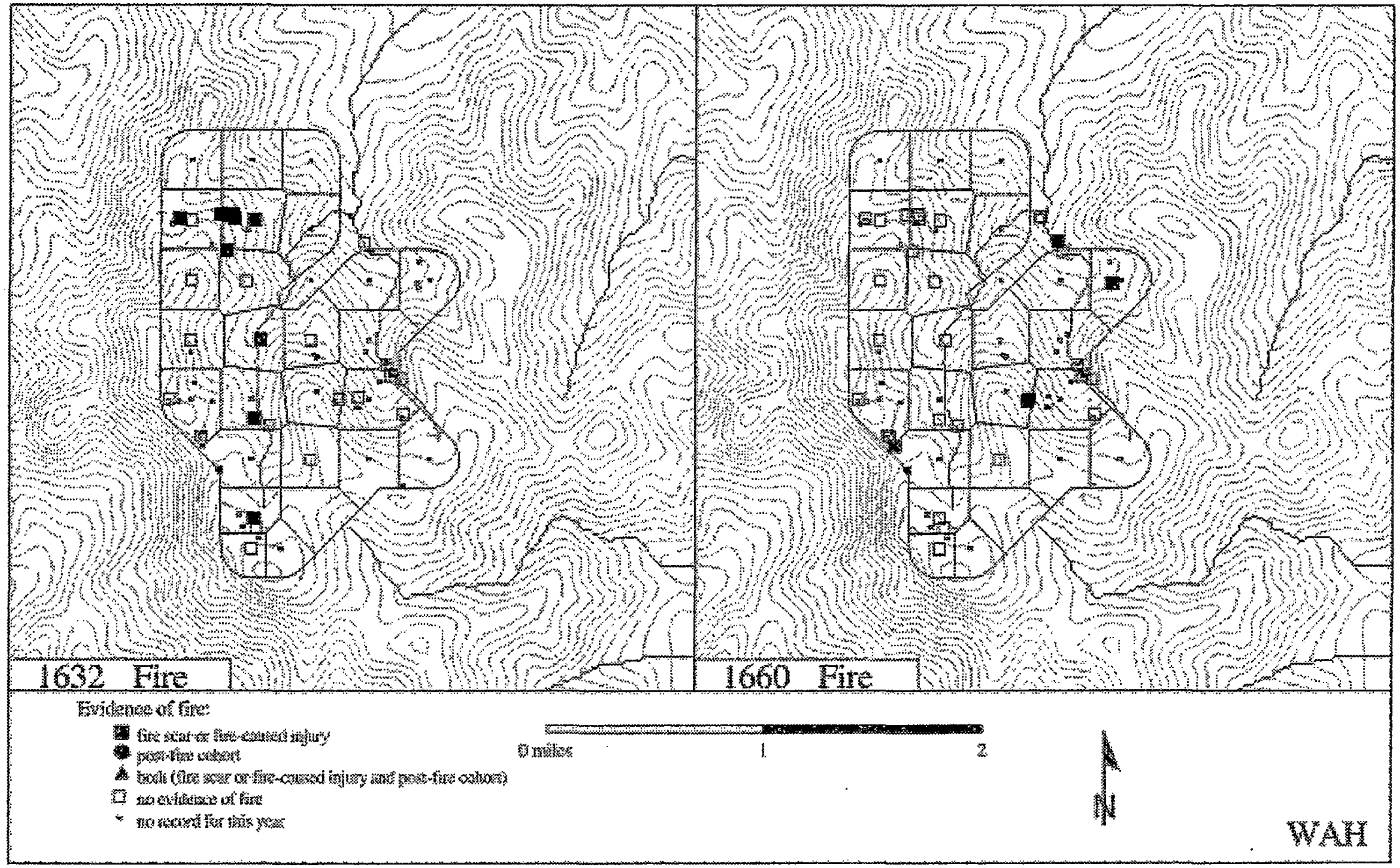
Maps of surface fires at WAH

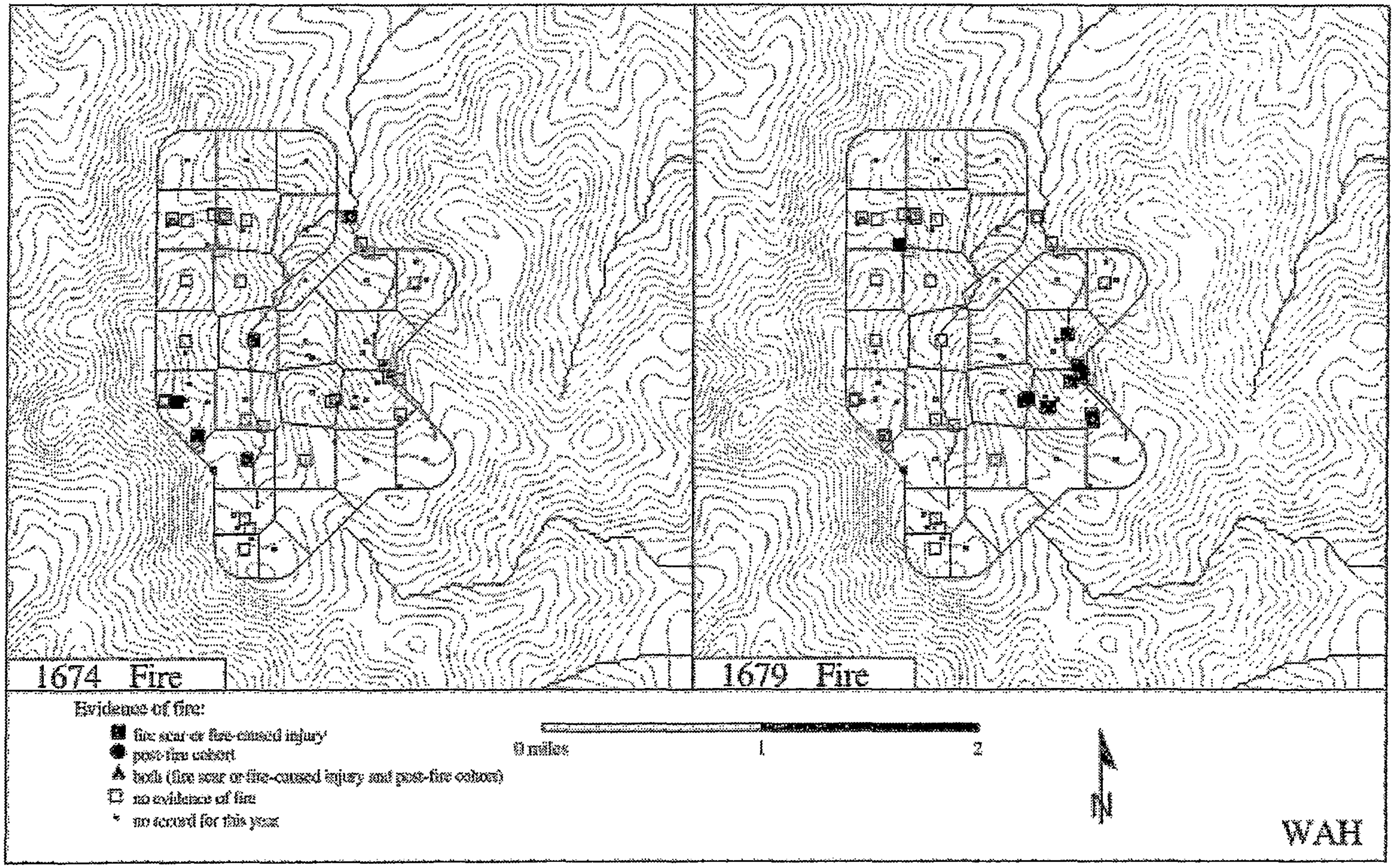
The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.

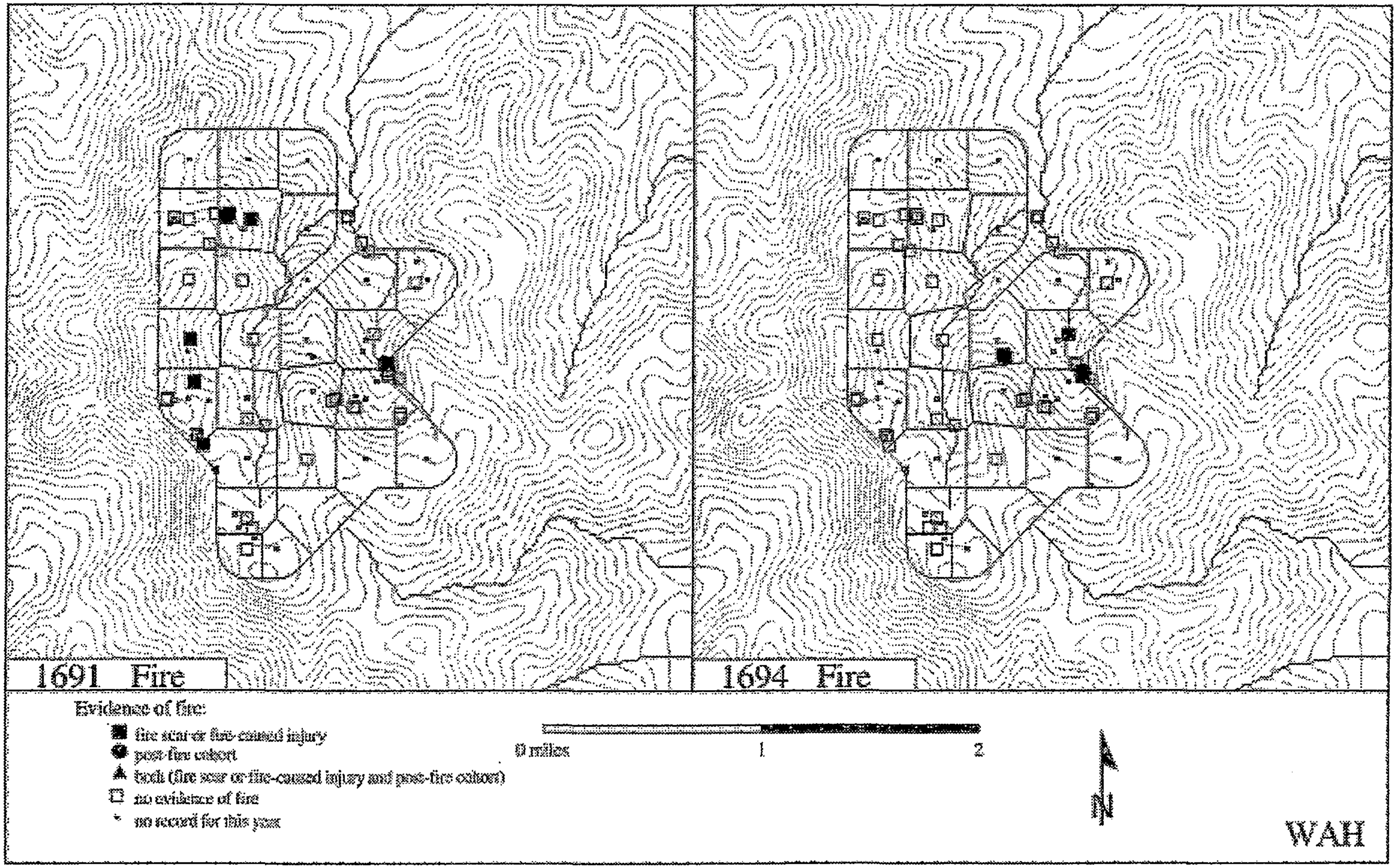


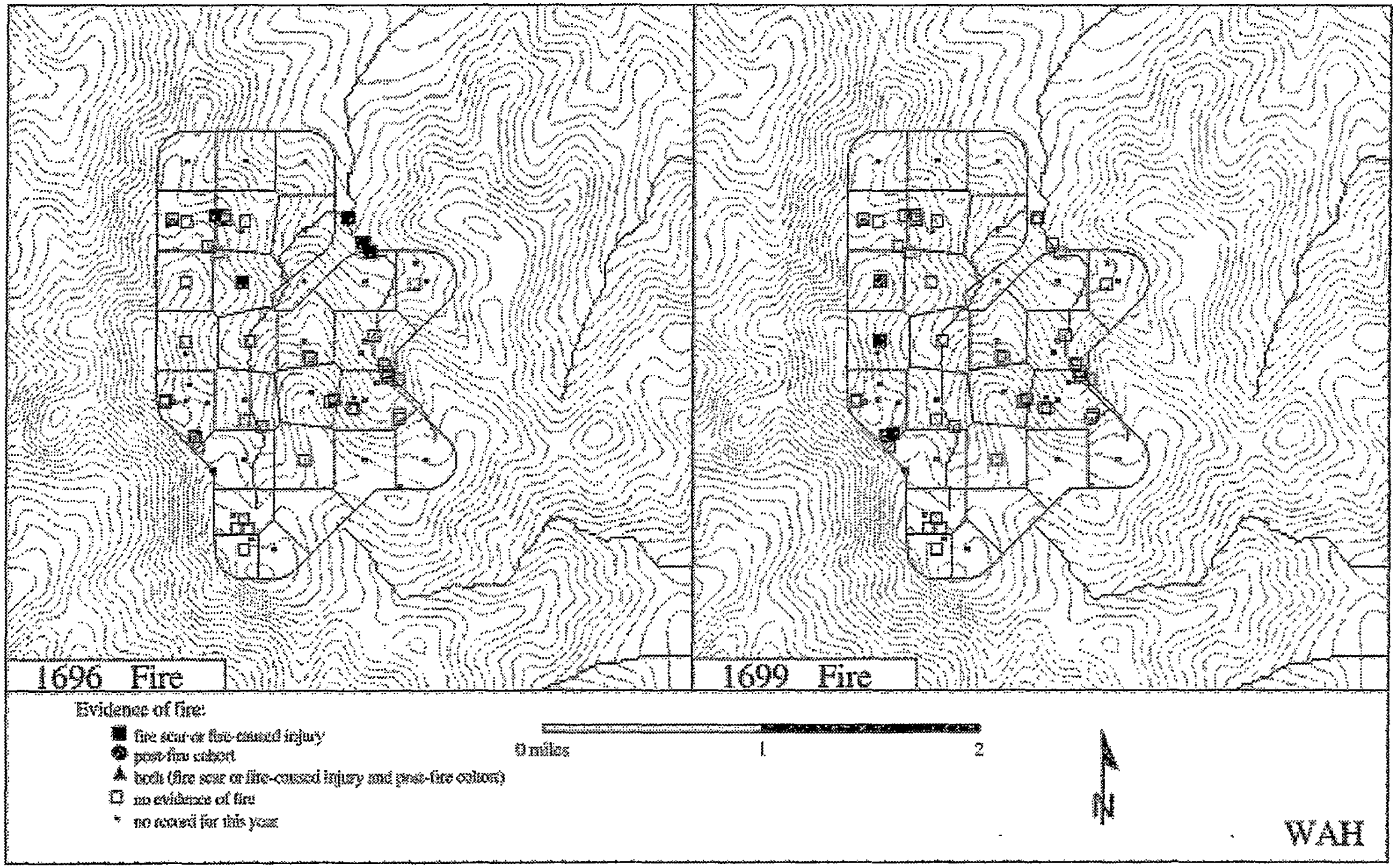
1423 Fire
1465 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH

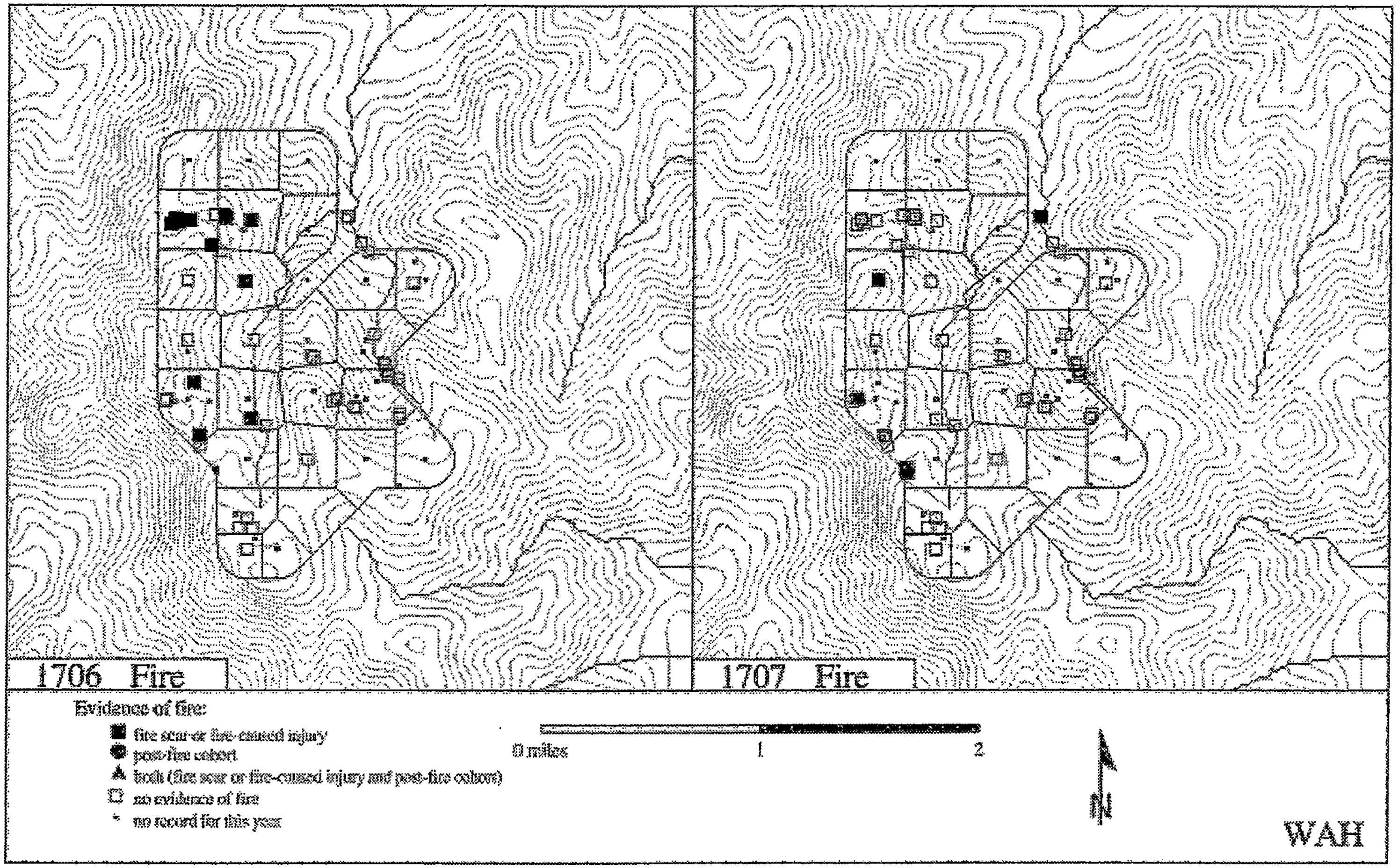

1506 Fire
1586 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH

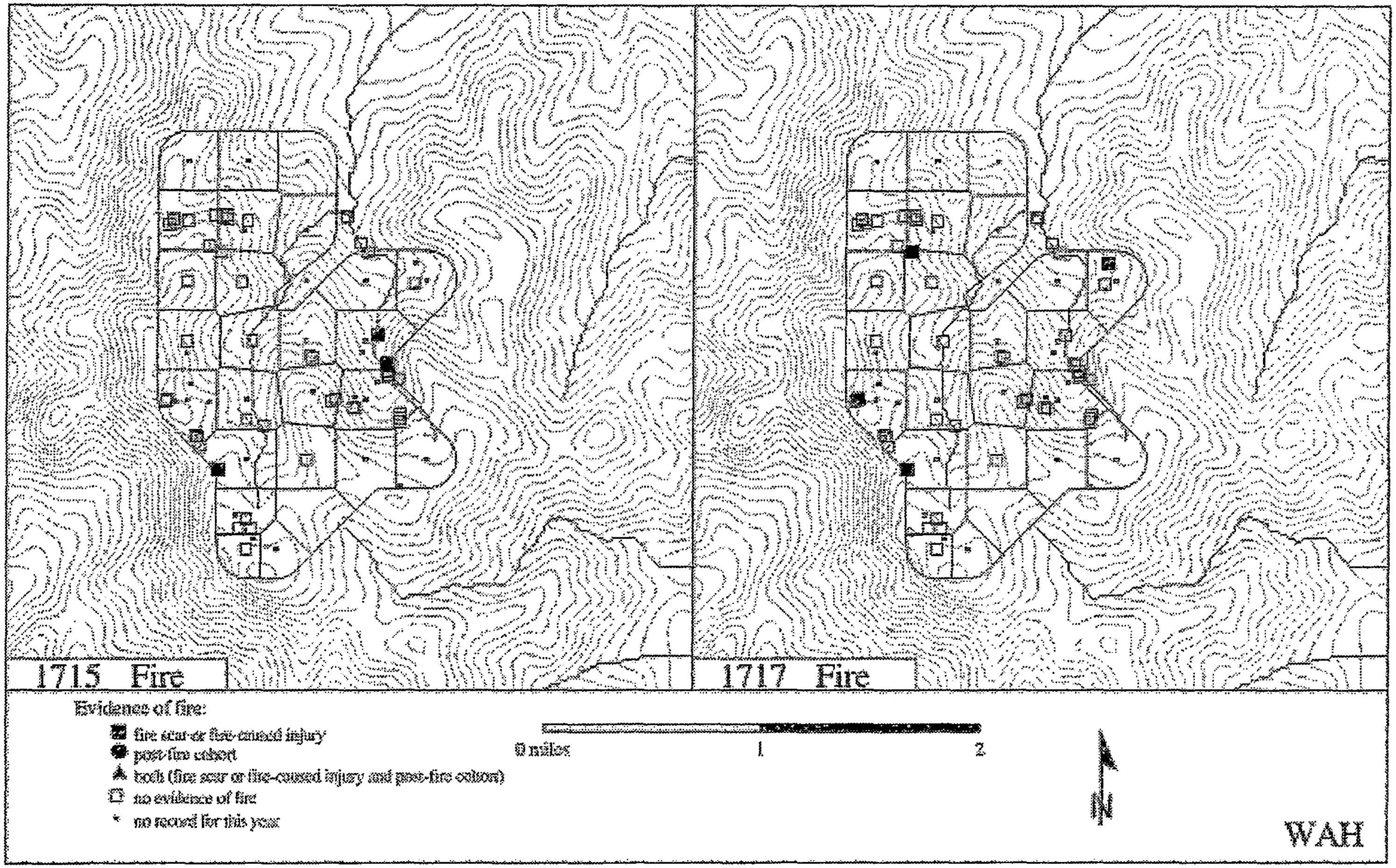

1632 Fire
1660 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH

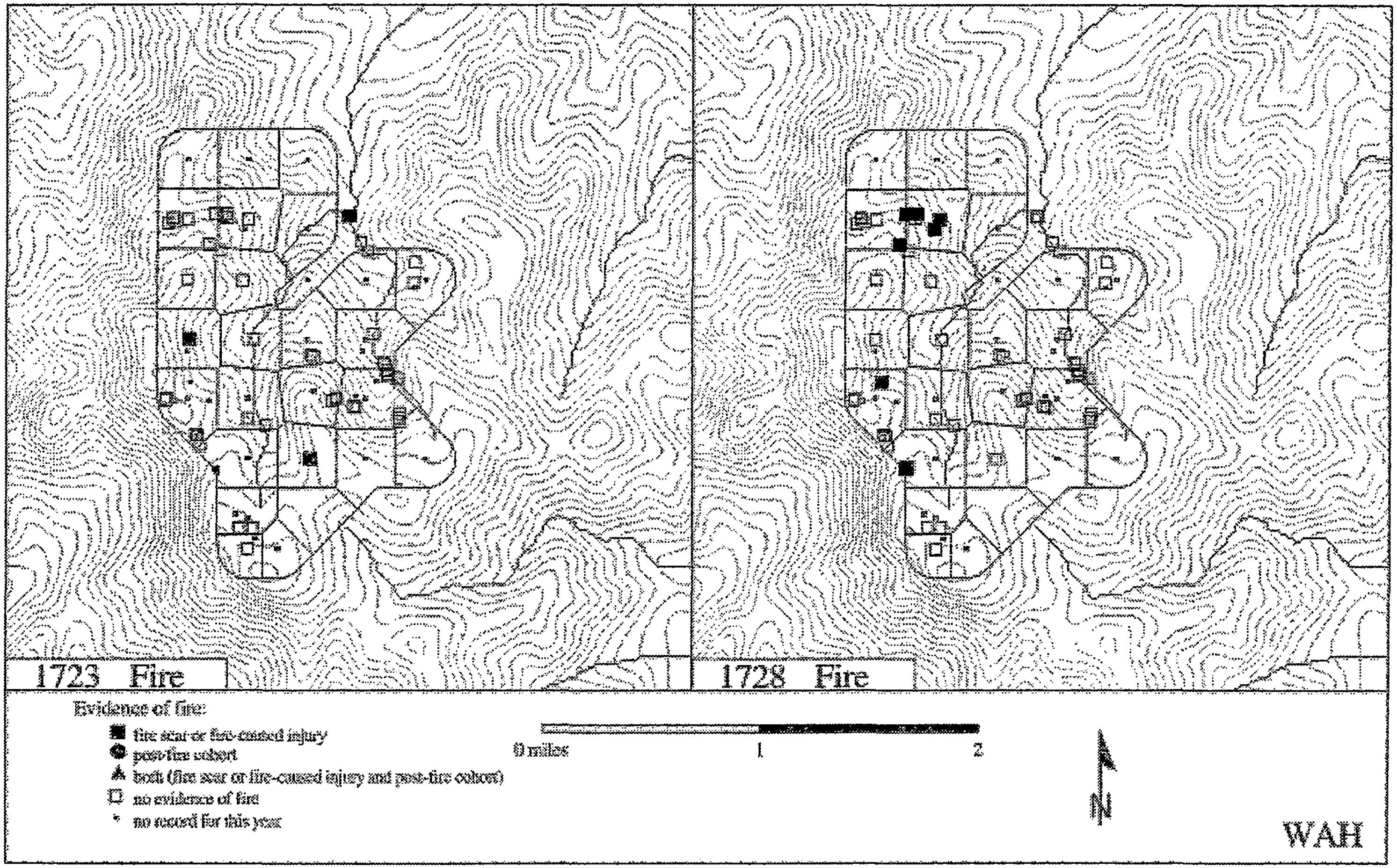

1674 Fire
1679 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH

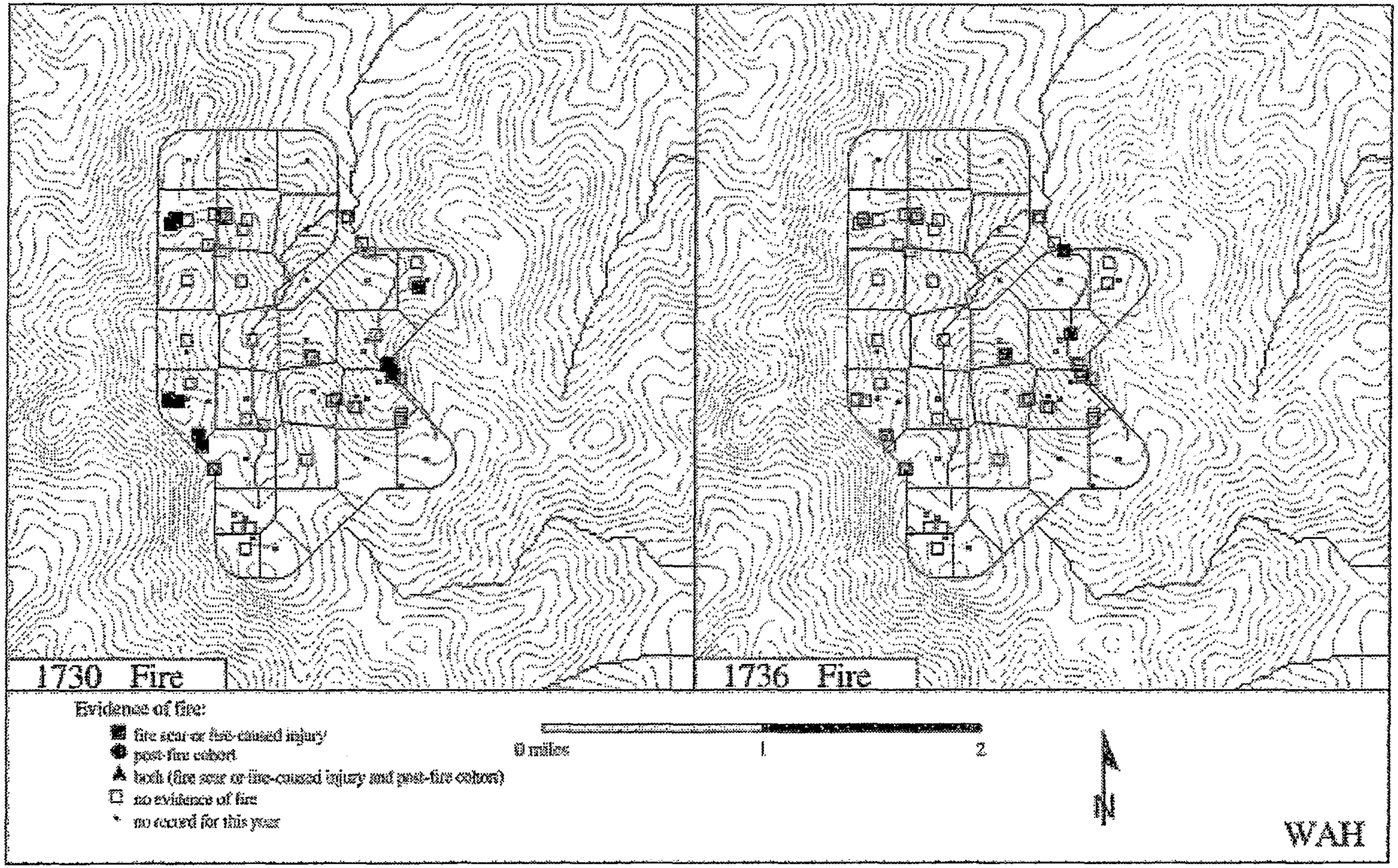

1691 Fire
1694 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH

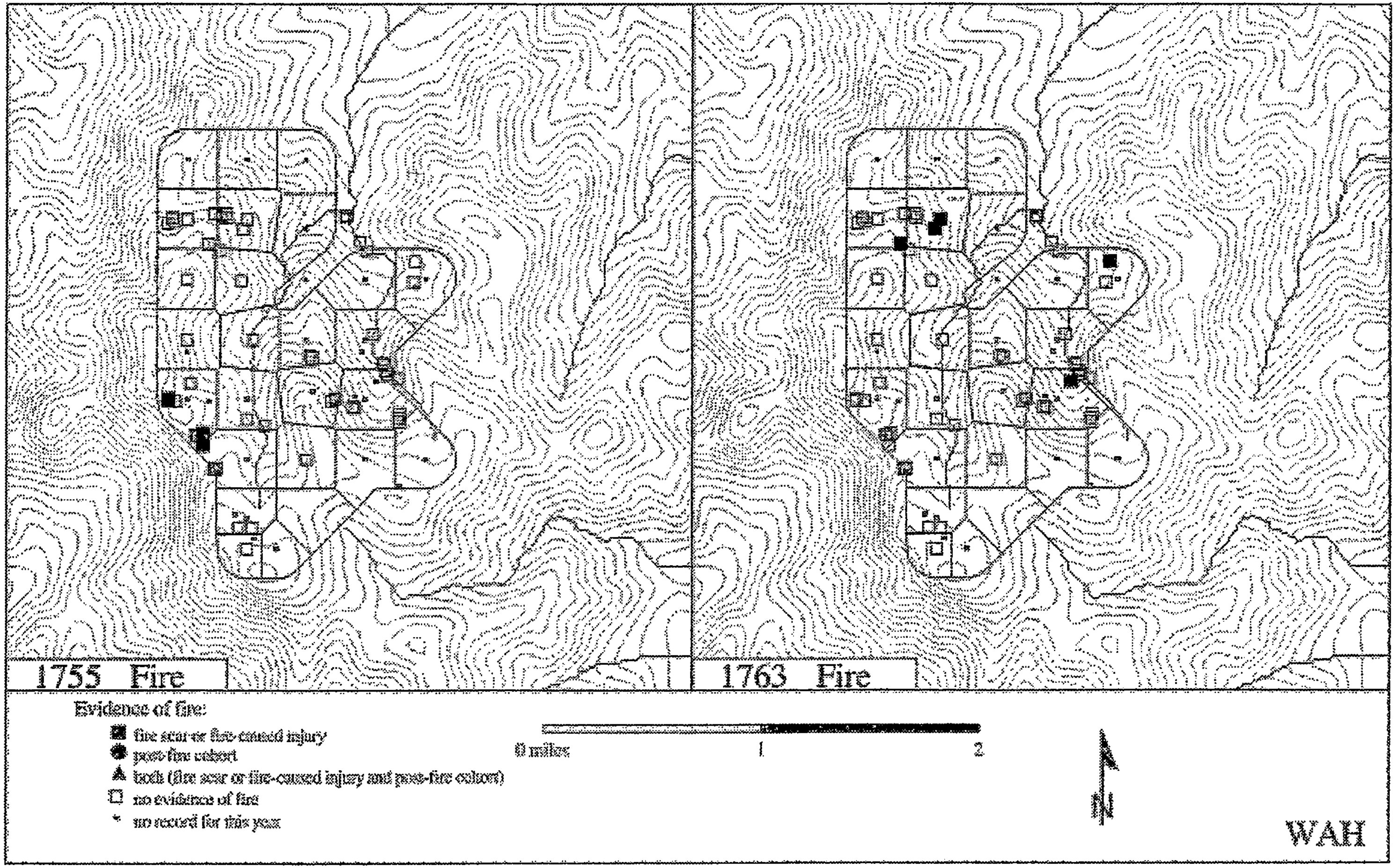

1696 Fire
1699 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH

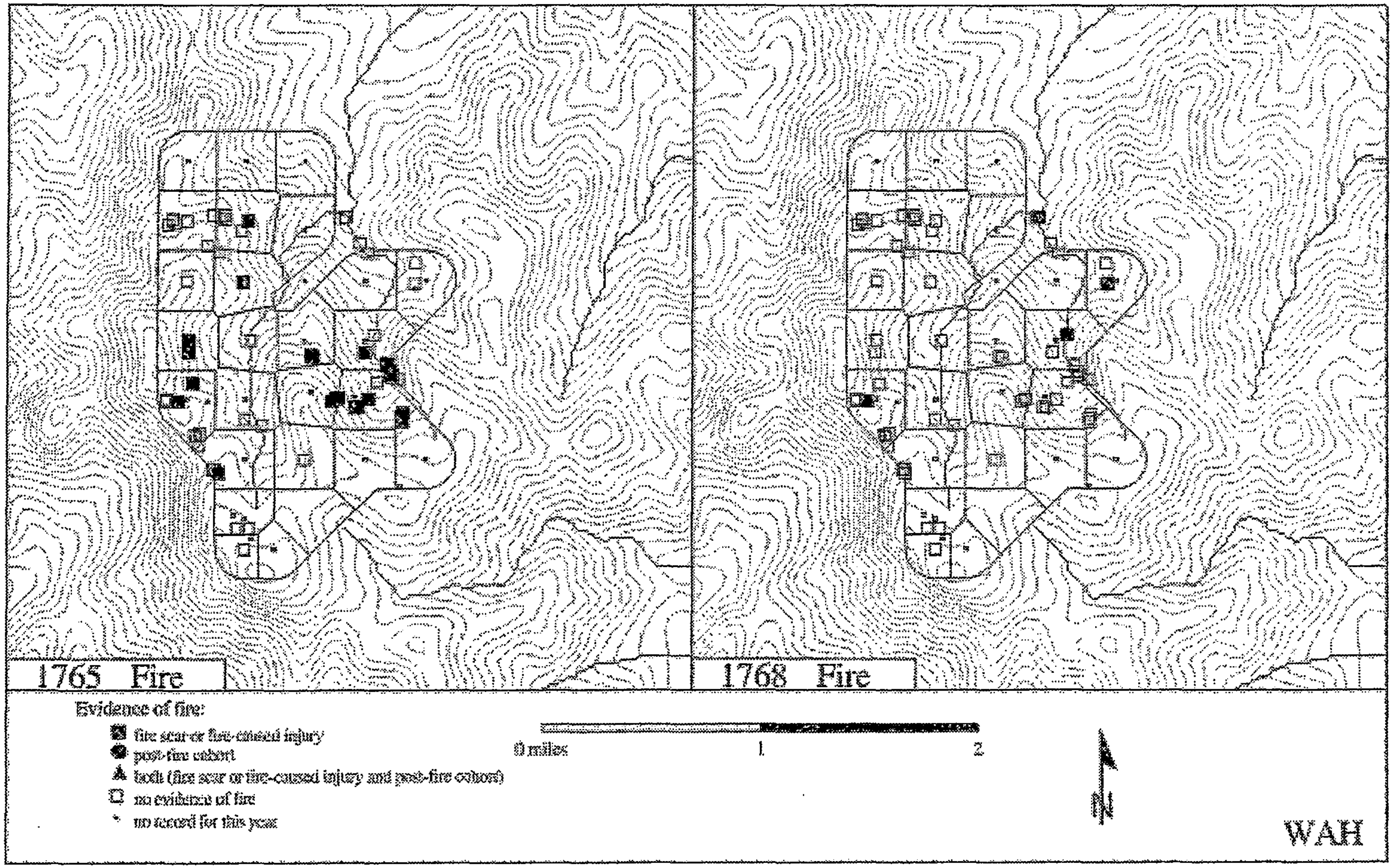

1706 Fire
1707 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH

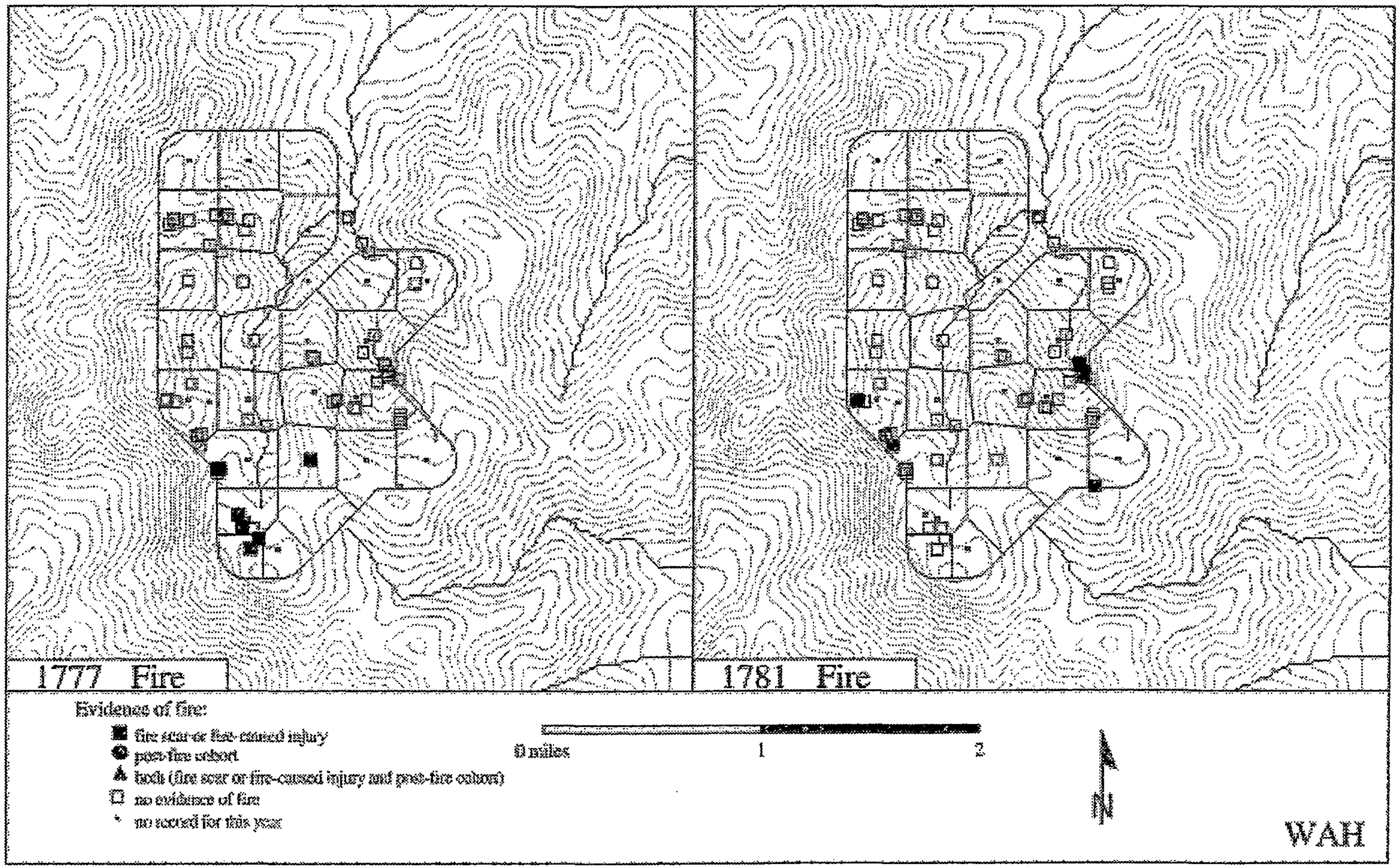

1715 Fire
1717 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH

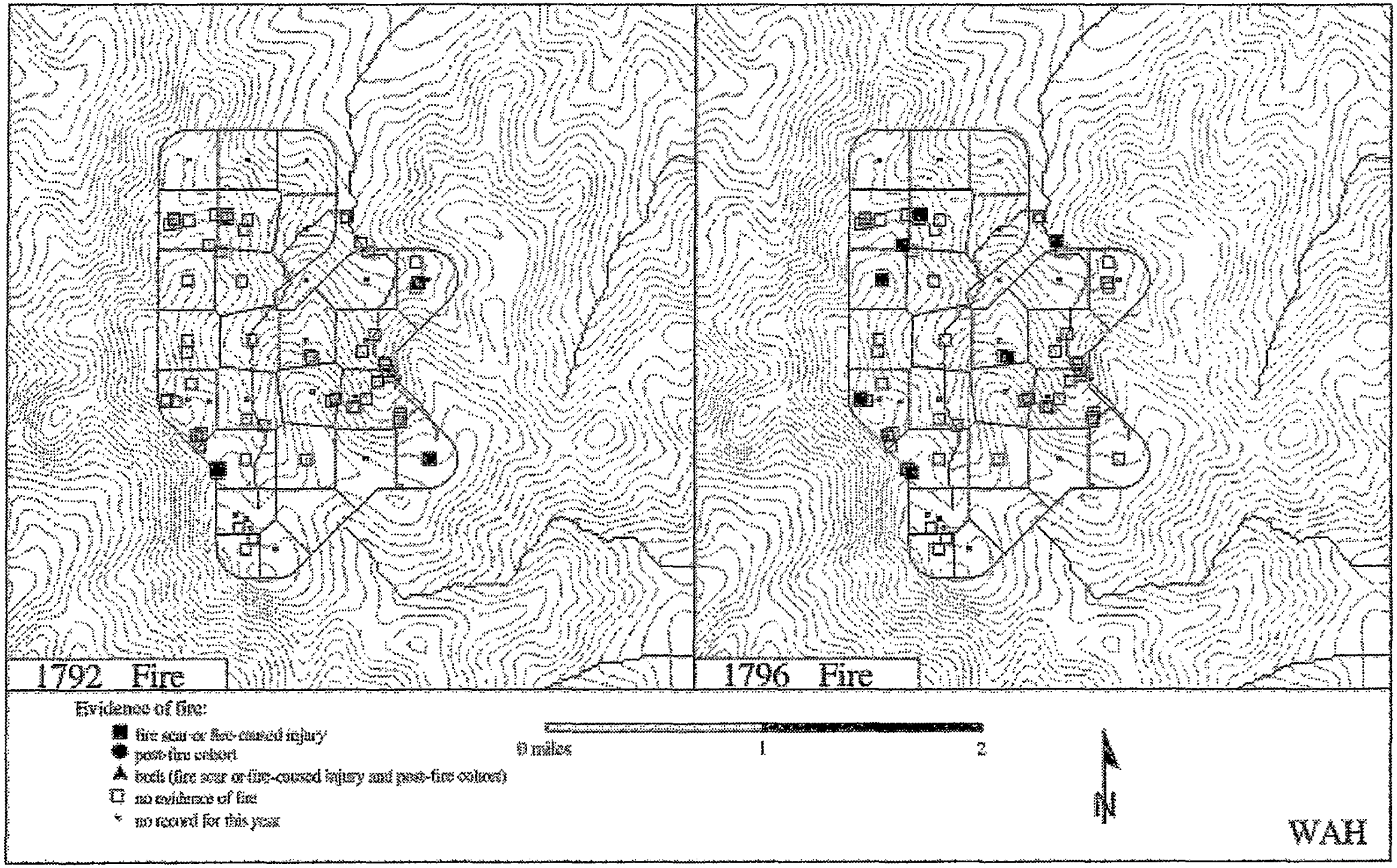

1723 Fire
1728 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH

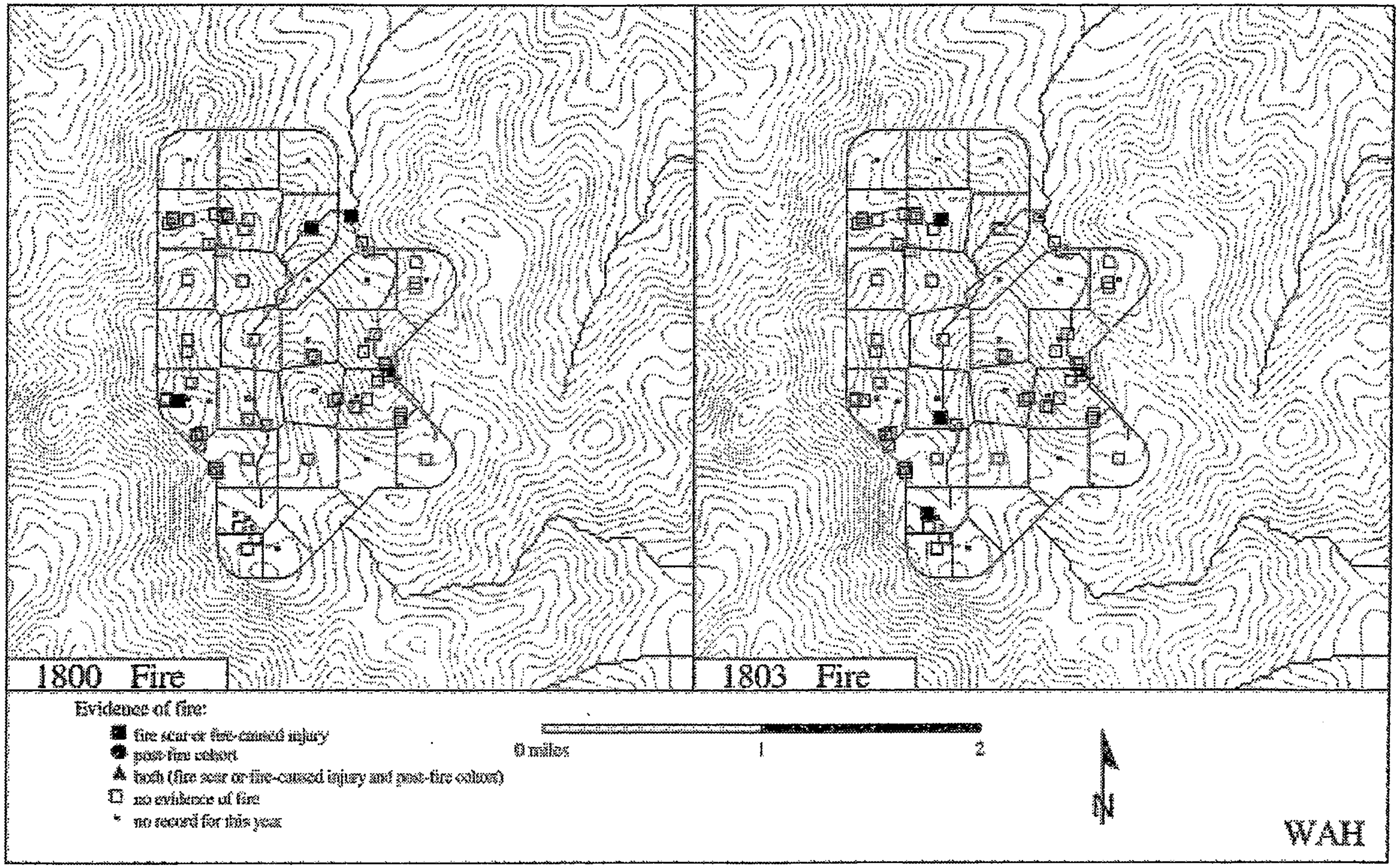

1730 Fire
1736 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH

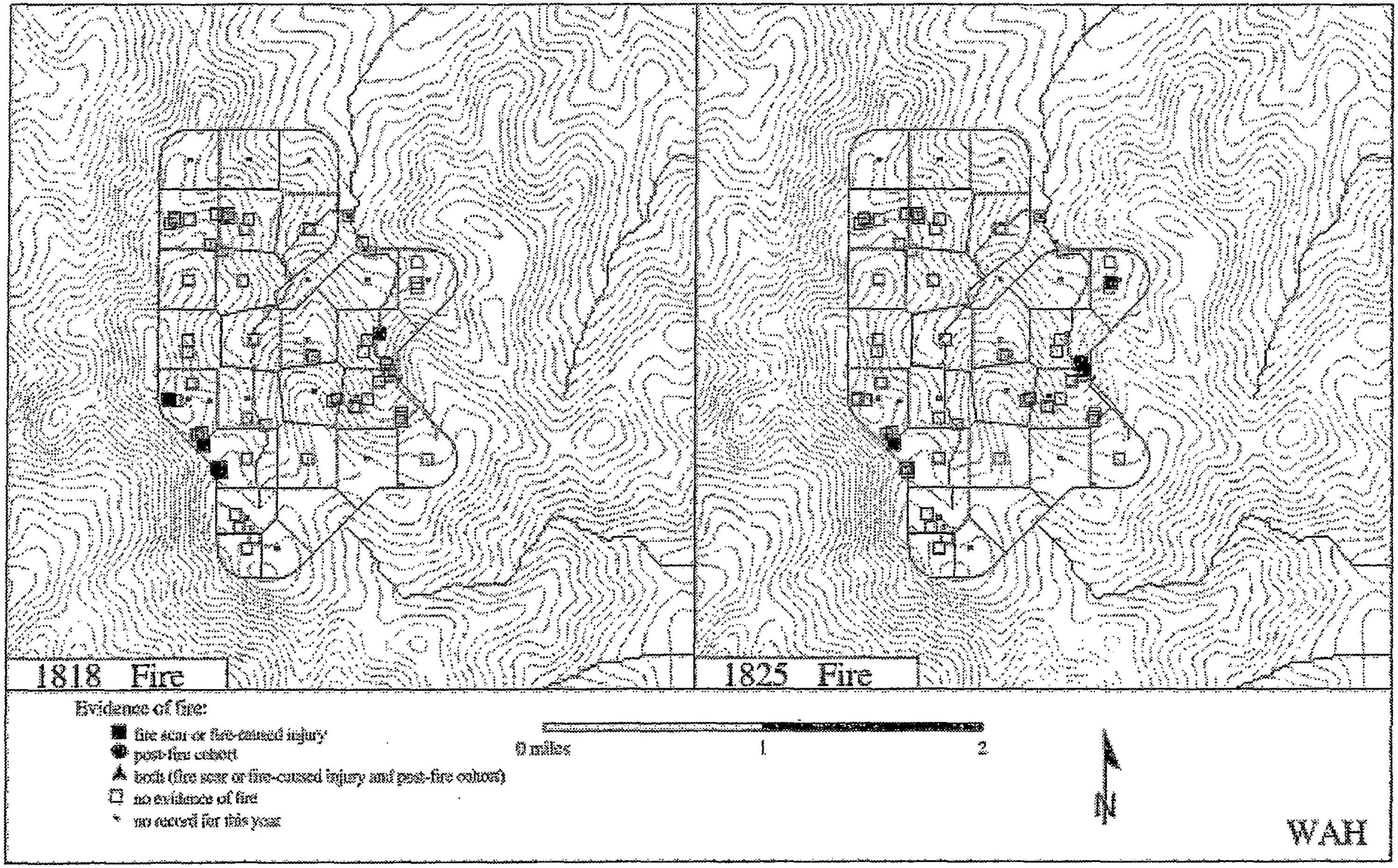

1755 Fire
1763 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH


1765 Fire
1768 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH


1777 Fire
1781 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH


1792 Fire
1796 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH


1800 Fire
1803 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH


1818 Fire
1825 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WAH

/

HENRY MOUNTAINS - BUREAU OF LAND MANAGEMENT (HNR)

Study Area

We sampled a grid of 30 plots over 1742 acres on Mount Ellen in the Henry Mountains, on the Richfield District, Bureau of Land Management in Garfield county, Utah (Figure 10). The plots ranged in elevation from 7895 to 10293 feet, and in slope from 5 to 64%. The plots were sampled on a range of aspects, although most plots were on south or west aspects (83%, Figure 11). The topography of the plots we sampled was generally similar to that of the sampling area at this site.

Results

Tree recruitment

Our plots included 868 total trees (94% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 835 trees and were able to crossdate most of these (693 trees, or 83% of sampled trees). The trees that occurred on our plots included a range of species (Figure 12). Trees were recruited into the sampled plots between 1325 and 1972, although most trees (80%) were recruited after 1803 (Figure 13).

Average tree density was higher at plots in 2000 than in 1860 for all 6 of the forest types that we assigned to the sampled plots at this site (sagebrush, pinyon-juniper, ponderosa, mixed conifer, aspen and spruce-fir, Figure 14, Table 2).

Surface fires

We removed fire-scarred sections from a total of 26 trees at HNR. We sampled only a few of these (17%) in the 2 of our 30 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were ponderosa pine (88%) or limber pine (8%), but we also sampled a few fire-scarred Douglas-fir. Some of the trees we sampled were logs, snags or stumps (40%), with the rest live trees. We were unable to crossdate sections from some of the sampled trees (31%). Those that we did crossdate yielded 97 fire scars, and 13 eroded fire scars or abrupt changes in ring width (1321 to 2003; Figure 15). We were able to assign an intra-ring position to 92% of the fire scars. Most of the scars from the analysis period (1650-1900) were created by fires burning early in the cambial growing season or when the cambium was dormant (85% of assigned scars, Figure 16).

The number of surface fires during the analysis period (1650-1900) varied with elevation and forest type at HNR (Figure 17). Surface fires ceased in the mid 1800s at this site (Figure 15).

Figures and tables for HNR

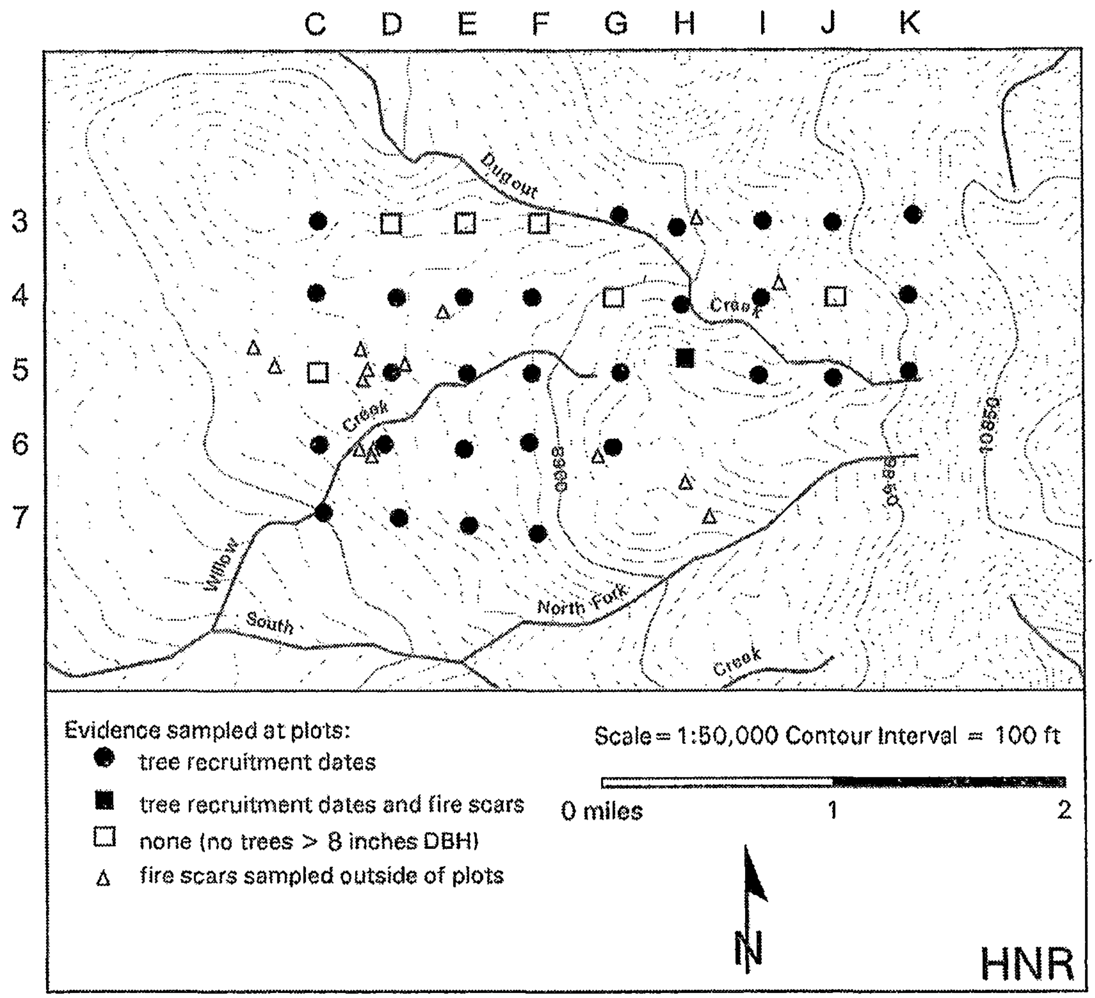


Figure 10. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the northwestern most plot is 3C, the next plot to the east is 3D, etc. A few of the fire-scarred trees (17% of 18 dated trees) were sampled within plots and so are not mapped individually.

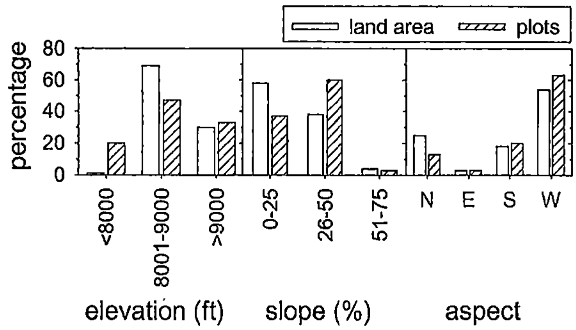


Figure 11. Distribution of topography for sampled plots and for land area at HNR. Aspect classes are 90° wide, beginning with 46° for east (E). Land area was derived from a digital elevation model.

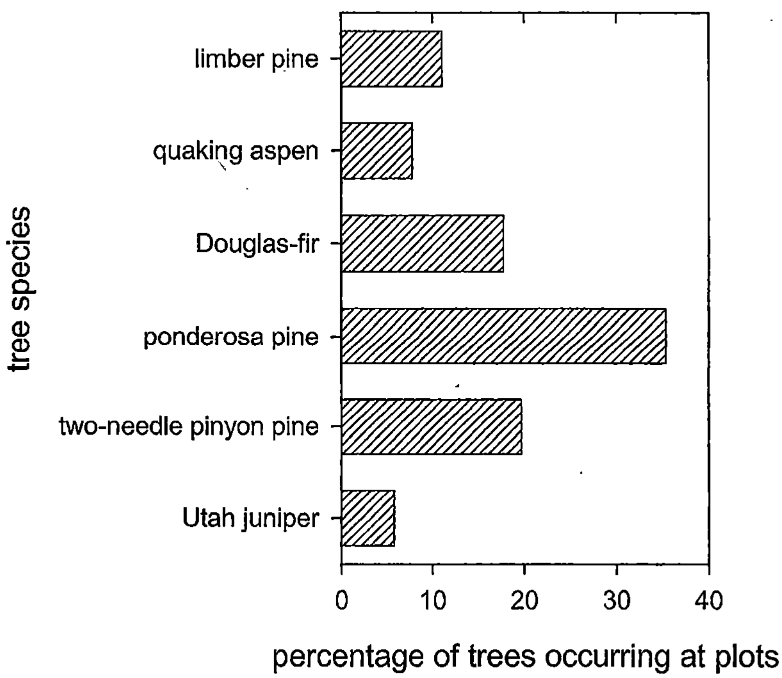


Figure 12. Species distribution of all trees that occurred in plots at HNR. In addition, 13 Engelmann spruce and 10 subalpine fir trees occurred in our plots but are not shown.

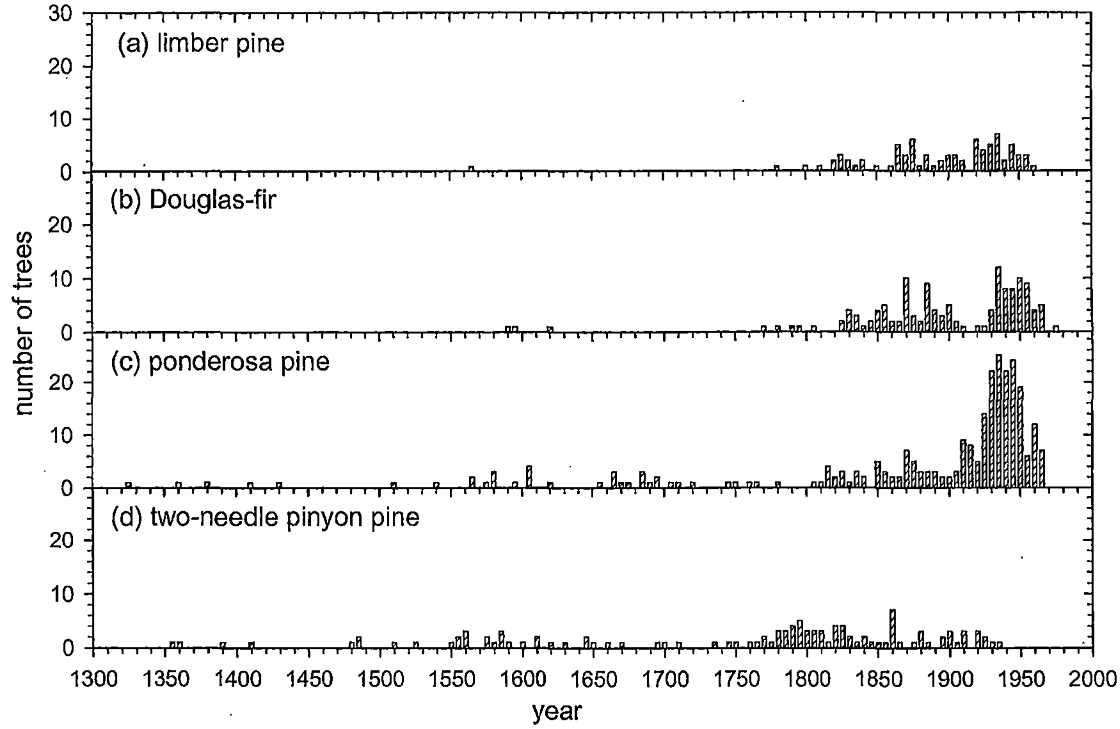


Figure 13. Distribution of tree-recruitment dates by species at HNR, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

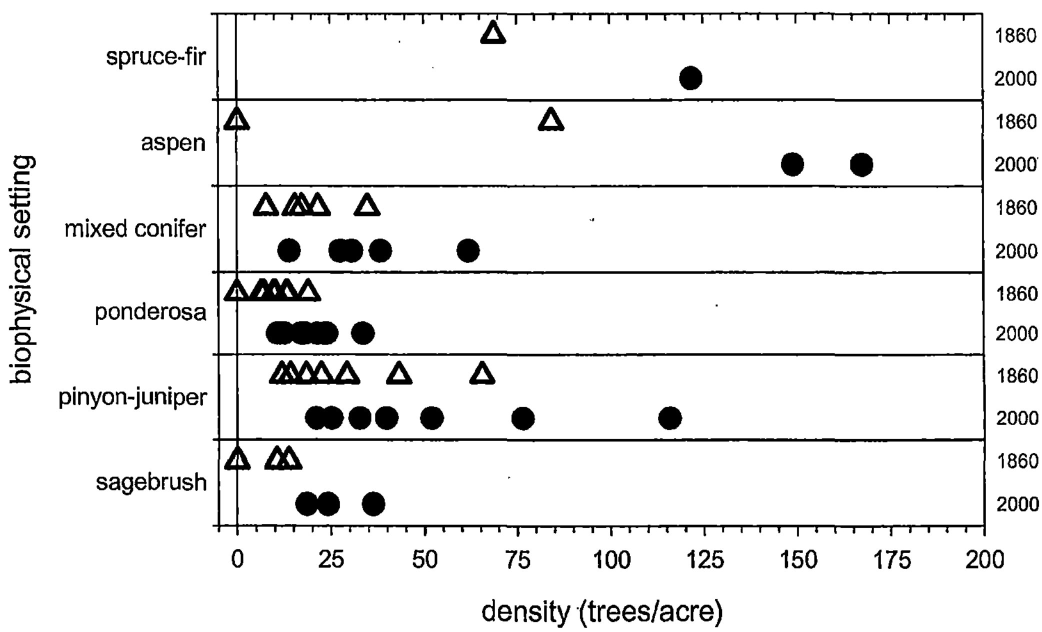


Figure 14. Density of live trees >8 inches DBH at each plot at HNR, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

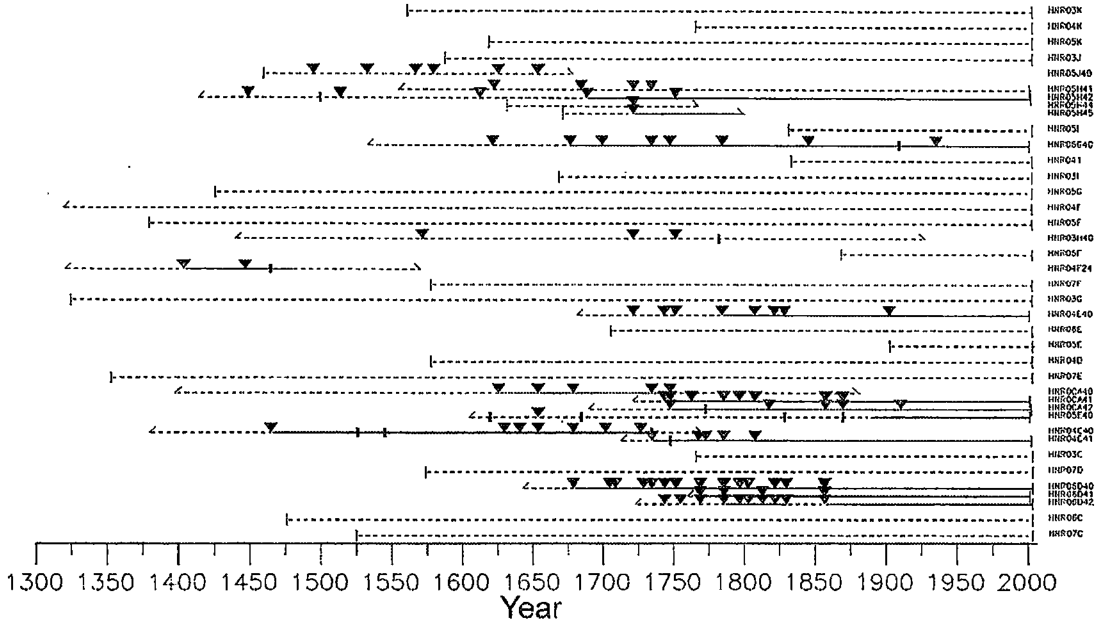


Figure 15. Fire chronologies at HNR, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

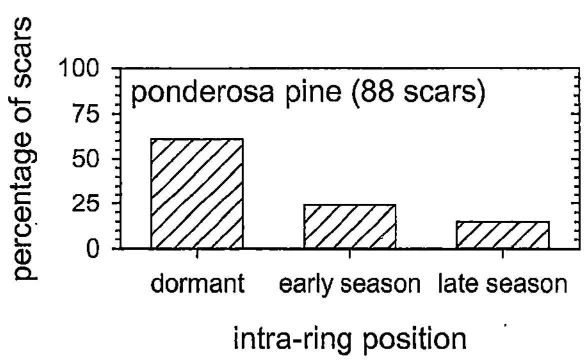


Figure 16. Intra-ring position of fire scars at HNR (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only species that comprised >10% of trees are plotted. We also dated scars from some limber pine, but this species yielded too few scars with an intra-ring position to plot here.

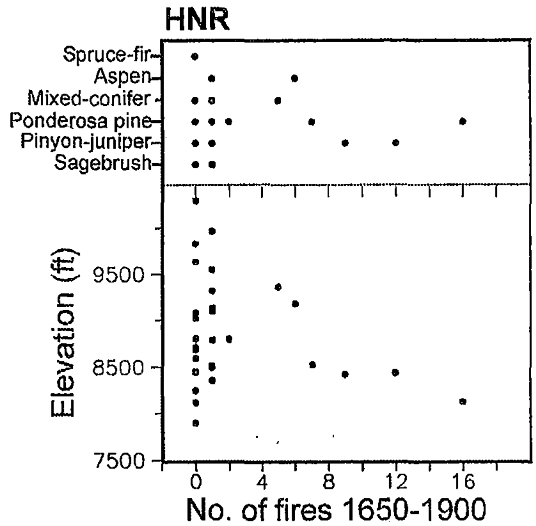
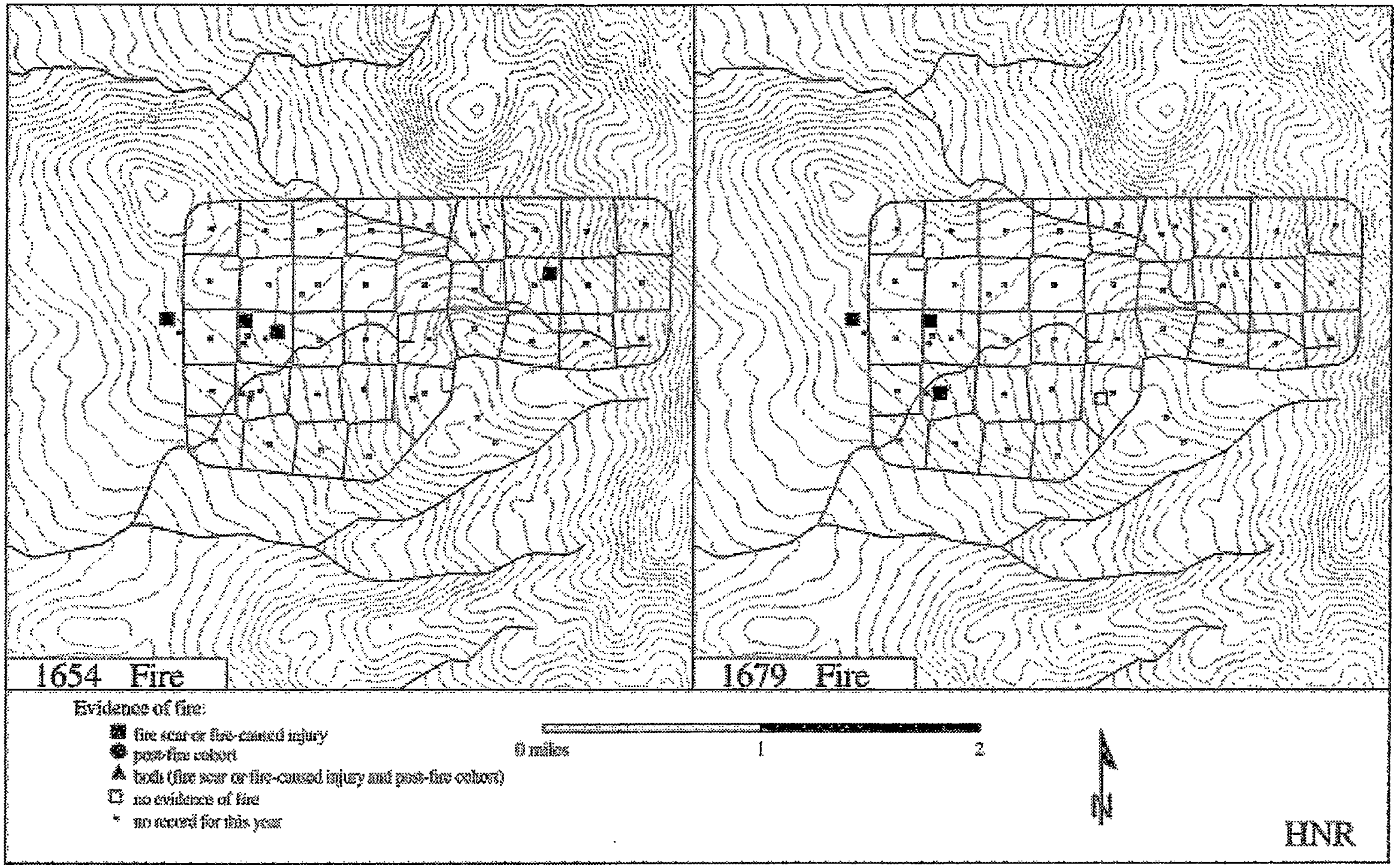
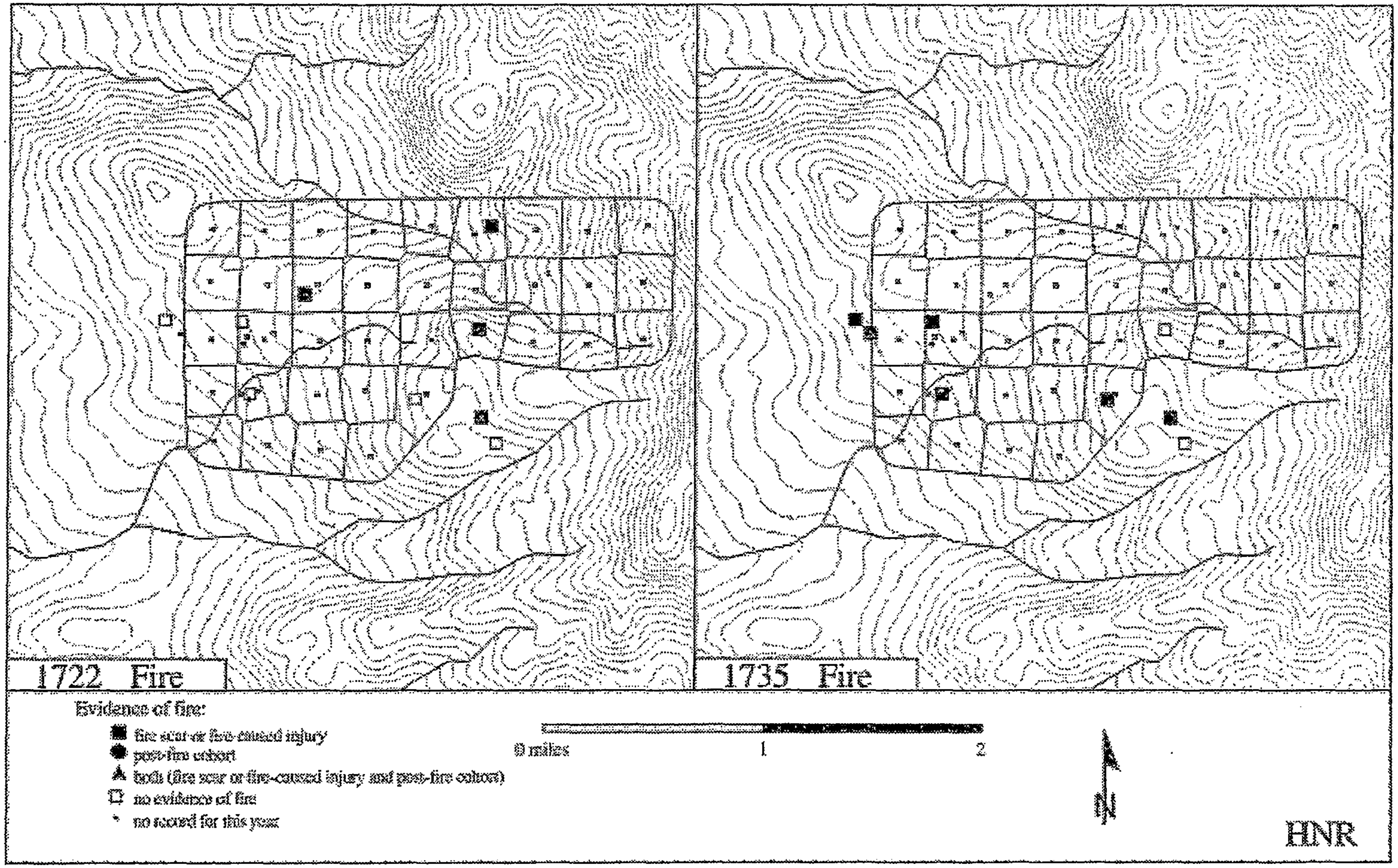


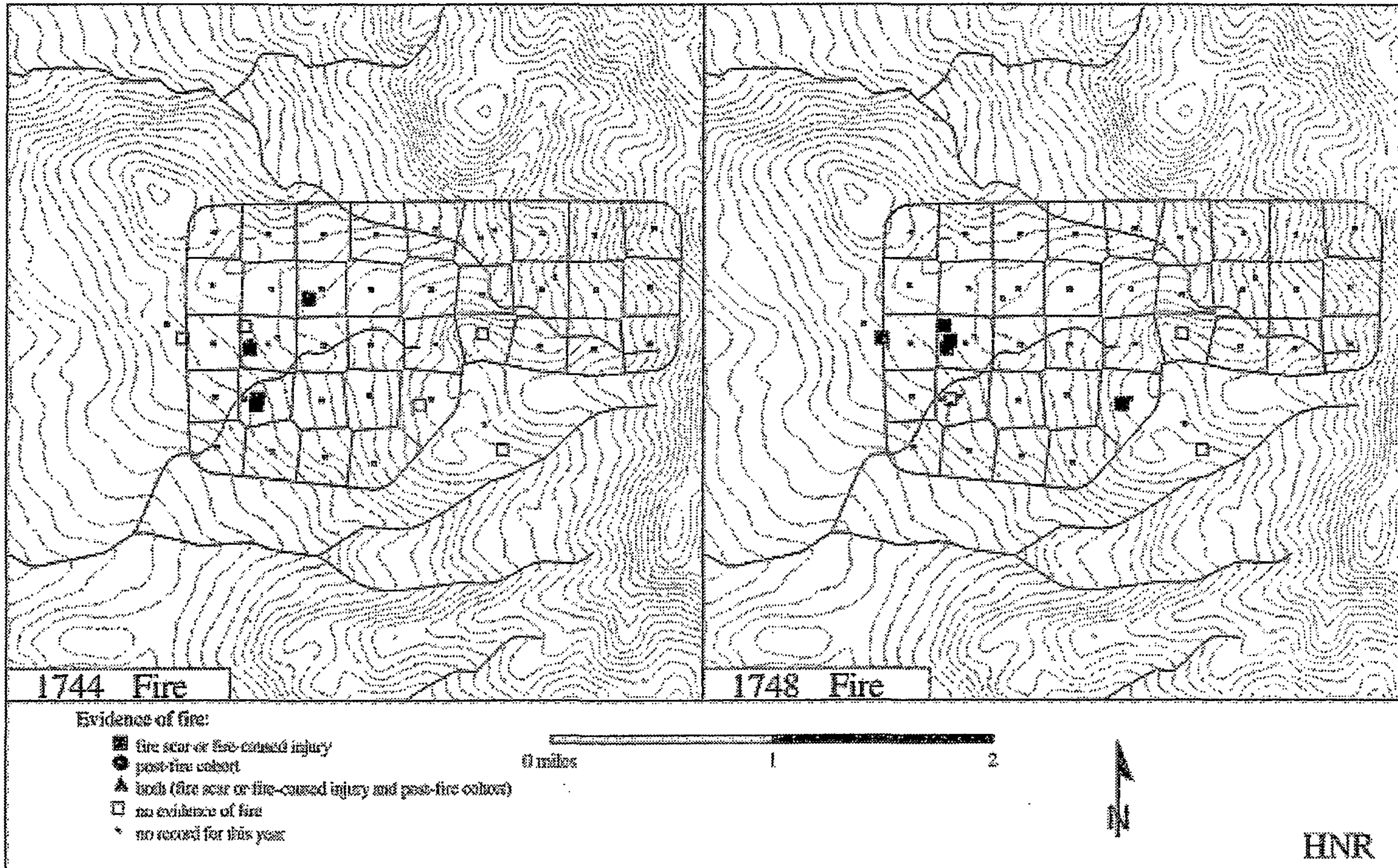
Figure 17. Number of fires within cells at HNR (1650-1900), by forest type (top panel, Table 2) and elevation (bottom panel). Number of fires includes only those fire years which were recorded on ≥2 trees at a site.

Maps of surface fires at HNR

The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.

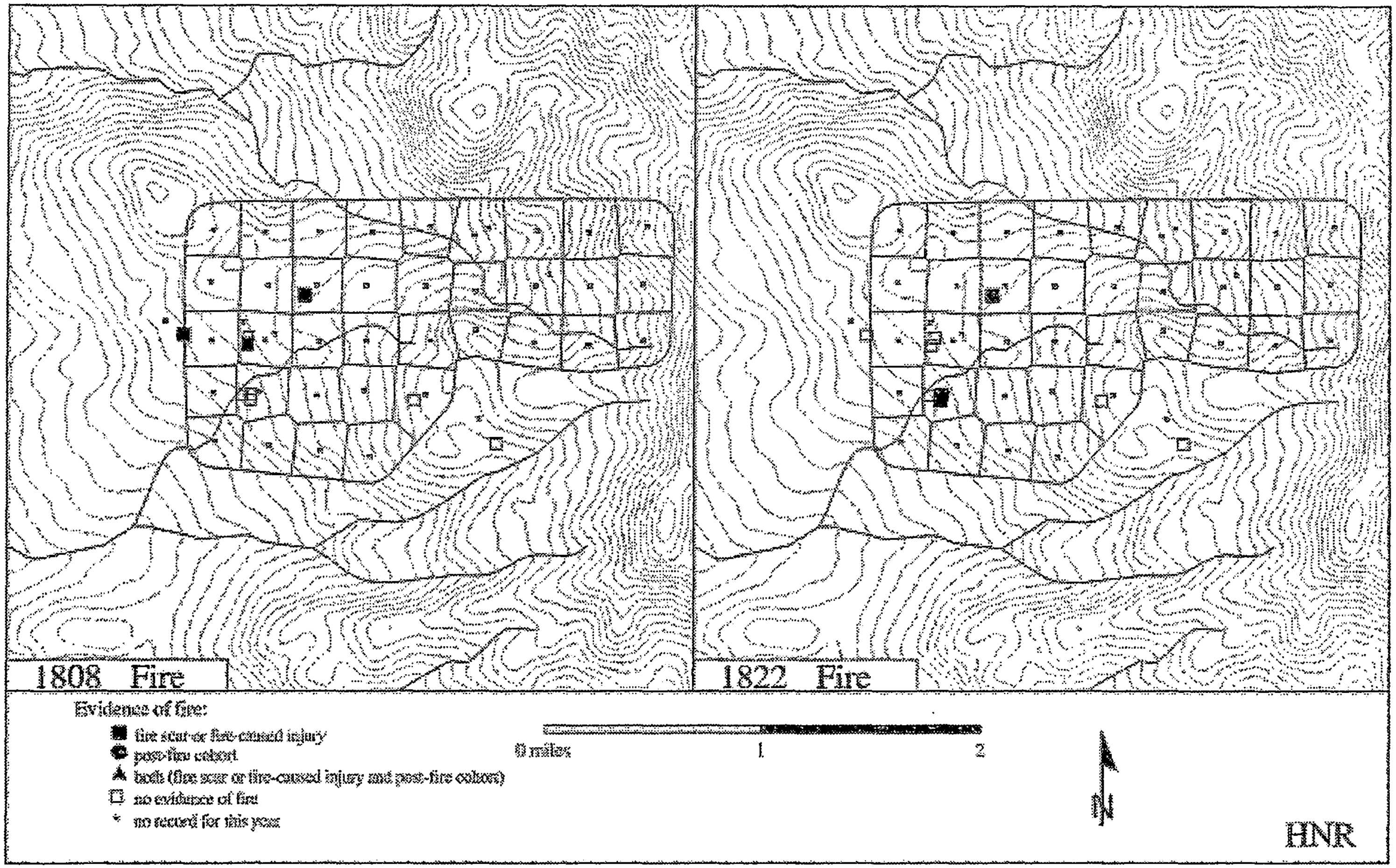

1654 Fire
1679 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
HNR

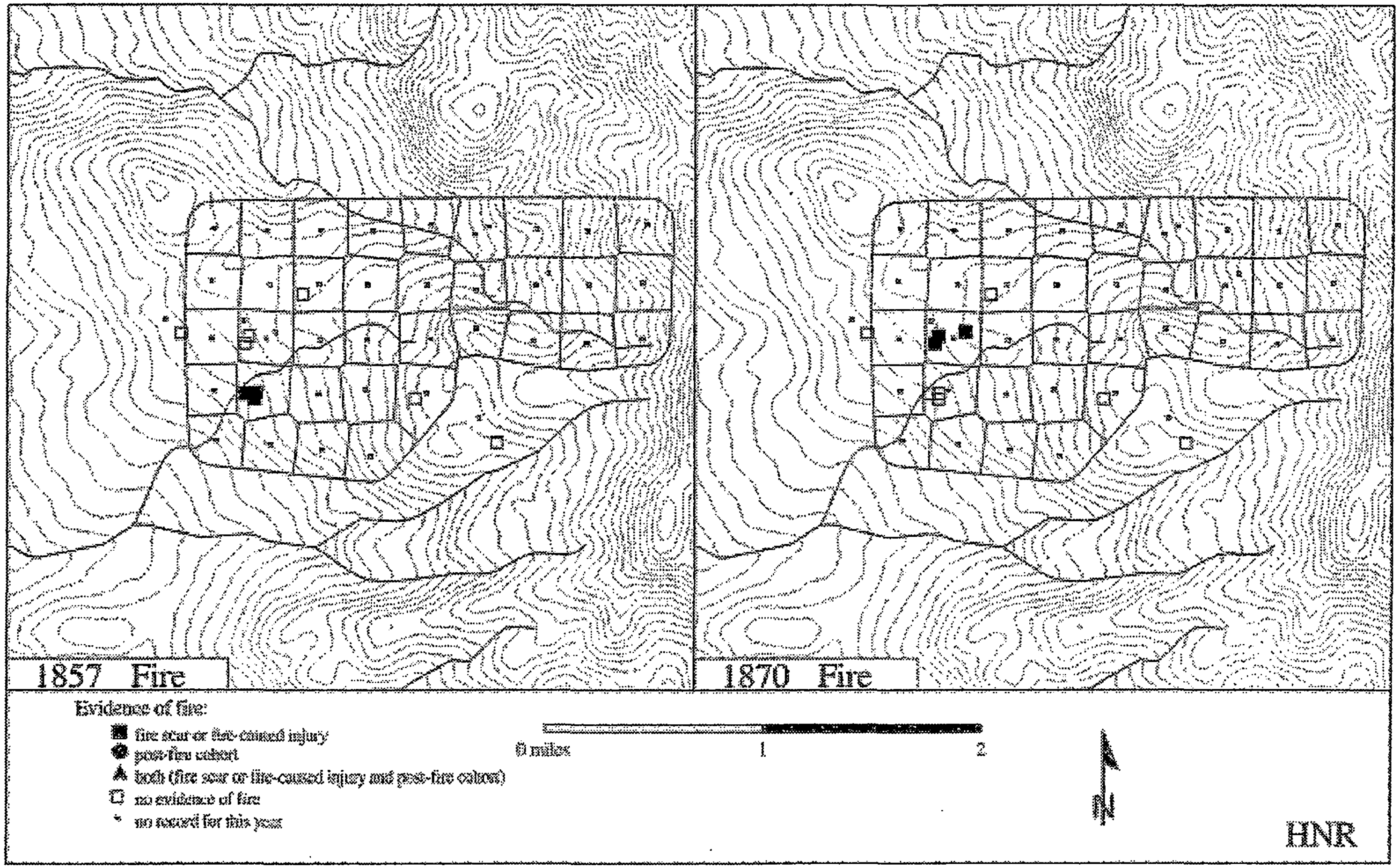

1722 Fire
1735 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
HNR


1744 Fire
1748 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
HNR


1752 Fire
1769 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
HNR


1786 Fire
1797 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
HNR


1808 Fire
1822 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
HNR


1857 Fire
1870 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
HNR

RAY MESA - BUREAU OF LAND MANAGEMENT (RAY)

The pinyon-juniper forest on Ray Mesa appears to have been established for several centuries, with the oldest trees that we sampled in our plots having recruited in the late 1500s (Figure 18). The stand may have established either after a crown fire prior to this date, or a severe drought in the late 1500s also may have killed overstory trees and opened up space for seedlings to become established, especially during the early 1600s which was very wet over much of the Colorado Plateau (e. g. , Brown and Wu 2005). Where we sampled ponderosa pine trees in plots RAY 1, 2 and 3 we found records of surface fires. These stands are open and support a grassy understory that is able to support surface fires. In the surrounding pinyon-juniper forest matrix, we did not see any evidence of surface fire or charred wood that would provide evidence of fire in these stands over the past 4 to 5 centuries. The forest on the mesa appears to be stable, with little evidence of land use effects over the 20th century.

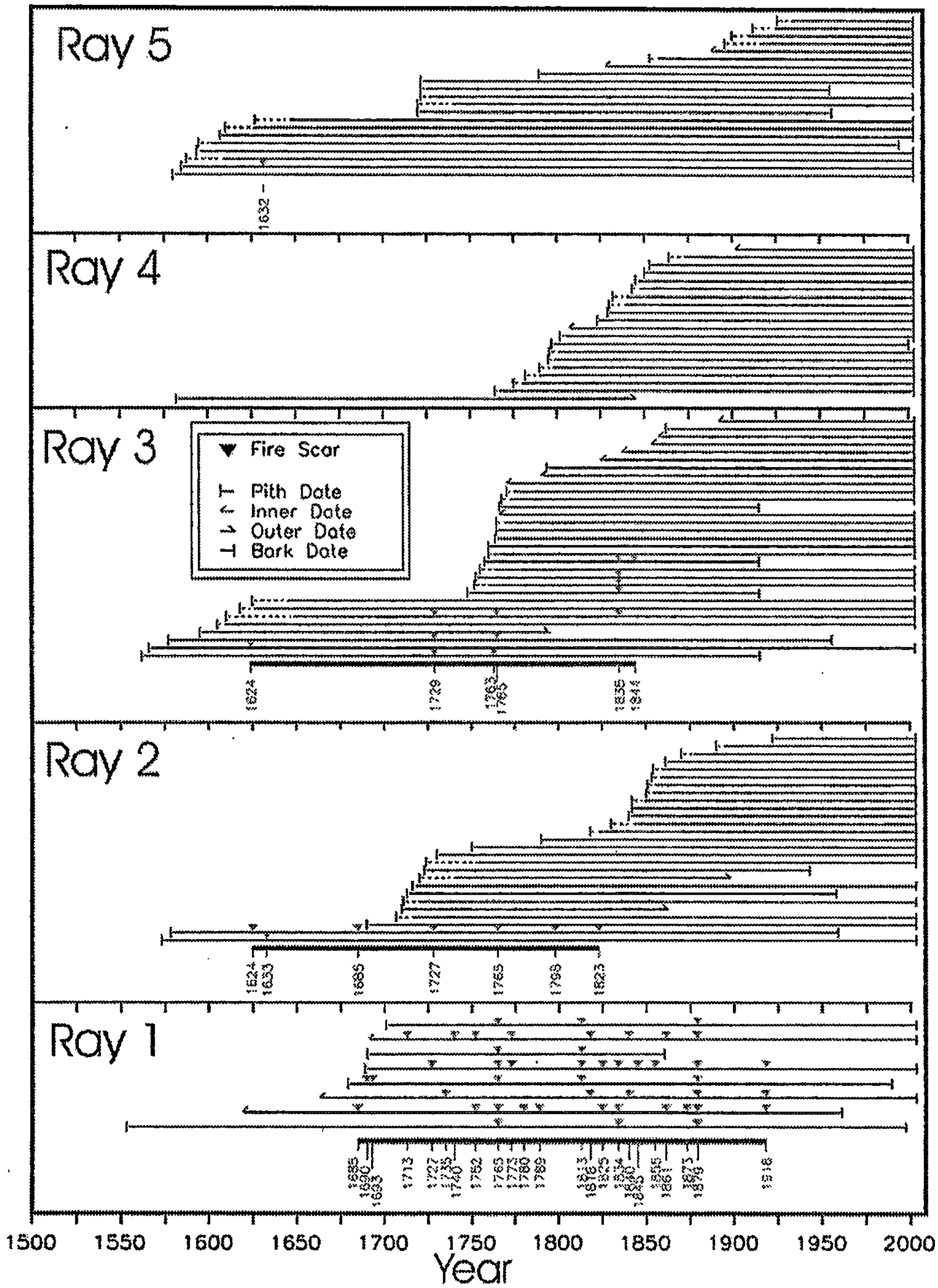


Figure 18. Fire chronologies at RAY (Grissino-Mayer 1995). Horizontal lines show the fire record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inner and outer dates are the dates of the earliest or latest rings sampled from trees where pith or bark was not sampled.

EAST TAVAPUTS PLATEAU - BUREAU OF LAND MANAGEMENT (BCL)

Study Area

We sampled a grid of 29 plots over 1303 acres near Pine Springs Canyon on the Vernal District, Bureau of Land Management, in Uintah county, Utah (Figure 19). The plots ranged in elevation from 6960 to 7360 ft, and the slope from 0-71%). The plots were sampled on a range of aspects(Figure 20). The topography of the plots we sampled was generally similar to that of the sampling area at this site.

Results

Tree recruitment

Our plots included 883 total trees (73% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 857 trees and were able to crossdate most of these (707 trees, or 82% of sampled trees). The trees that occurred on our plots included a range of species (Figure 21). Trees were recruited into the sampled plots between 1220 and 1978, although most trees (80%) were recruited after 1583 (Figure 22).

Average tree density was higher at plots in 2000 than in 1860 for all 3 of the forest types that we assigned to the sampled plots at this site (pinyon-juniper, ponderosa and mixed conifer, Figure 23, Table 2).

Surface fires

We removed fire-scarred sections from a total of 33 trees at BCL. We sampled almost half of these (48%) in the 7 of our 29 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were ponderosa pine (84%) or Douglas-fir (13%), but we also sampled a few fire-scarred two-needle pinyon. Most of the trees we sampled were logs, snags or stumps (66%), with the rest live trees. We were unable to crossdate sections from some of the sampled trees (24%). Those that we did crossdate yielded 26 fire scars, and 2 eroded fire scars or abrupt changes in ring width (1289 to 2004; Figure 24). Too few fire scars with season determined (3 scars) occurred during the analysis period (1650-1900) for us to determine the distribution of scars by intra-ring position. There were not enough fire scars during the analysis period for us to compute the number of fires by elevation or by forest type.

Figures and tables for BCL

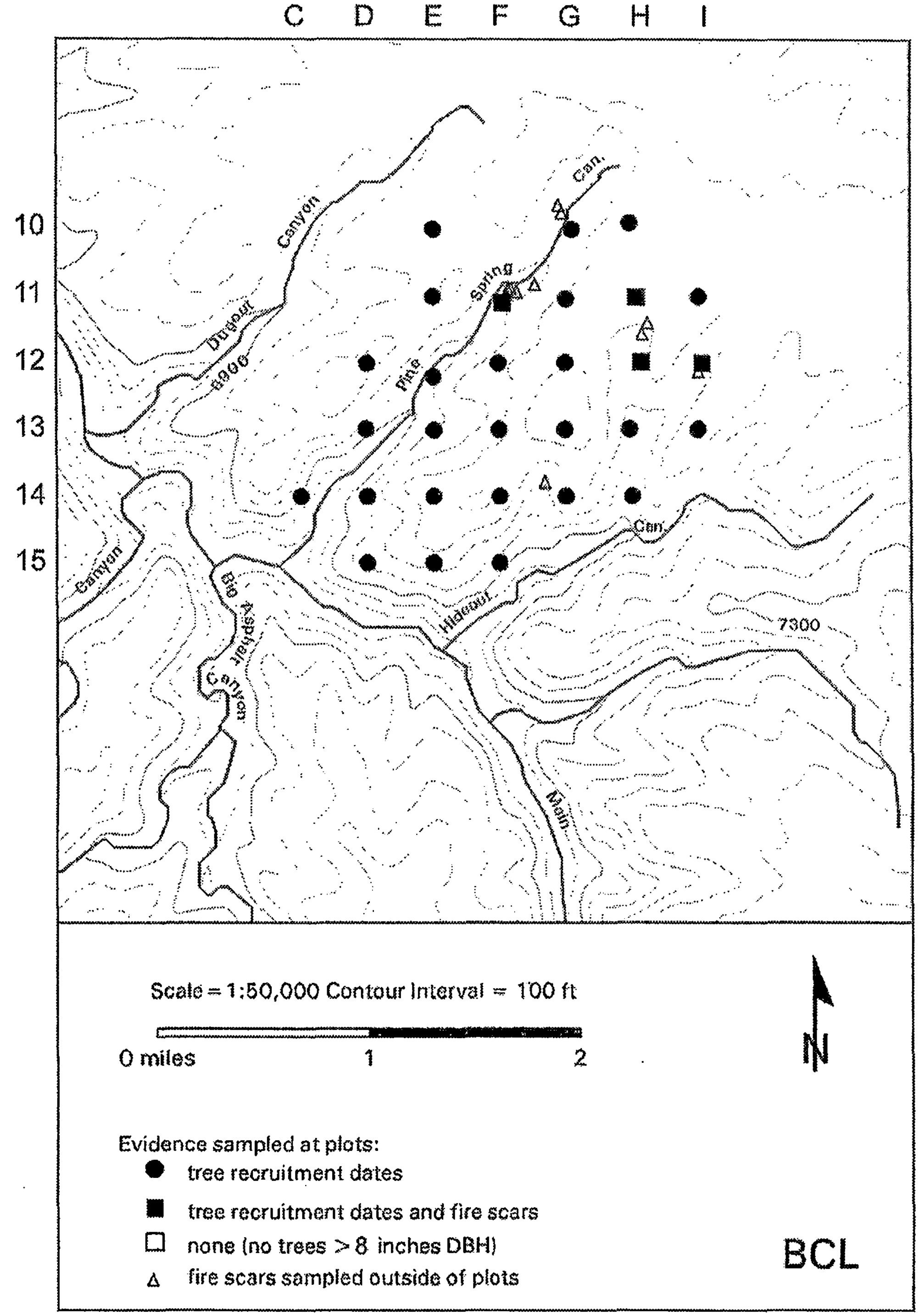


Figure 19. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the northwestern most plot is 10C, the next plot to the east is 10D, etc. Many of the fire-scarred trees (48% of 25 dated trees) were sampled within plots and so are not mapped individually.

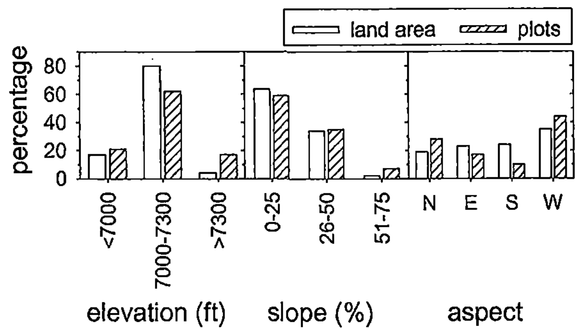


Figure 20. Distribution of topography for sampled plots and for land area at BCL. Aspect classes are 90° wide, beginning with 46° for east (E). Land area was derived from a digital elevation model.

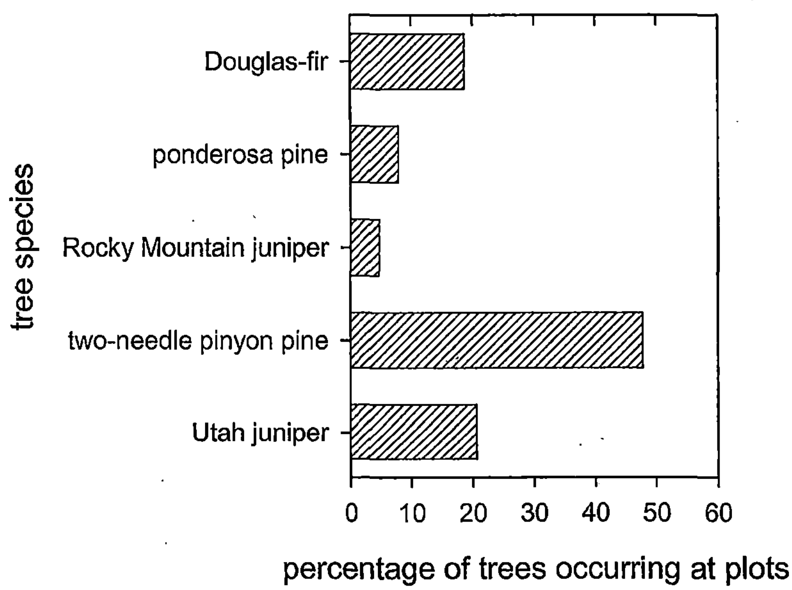


Figure 21. Species distribution of all trees that occurred in plots at BCL.

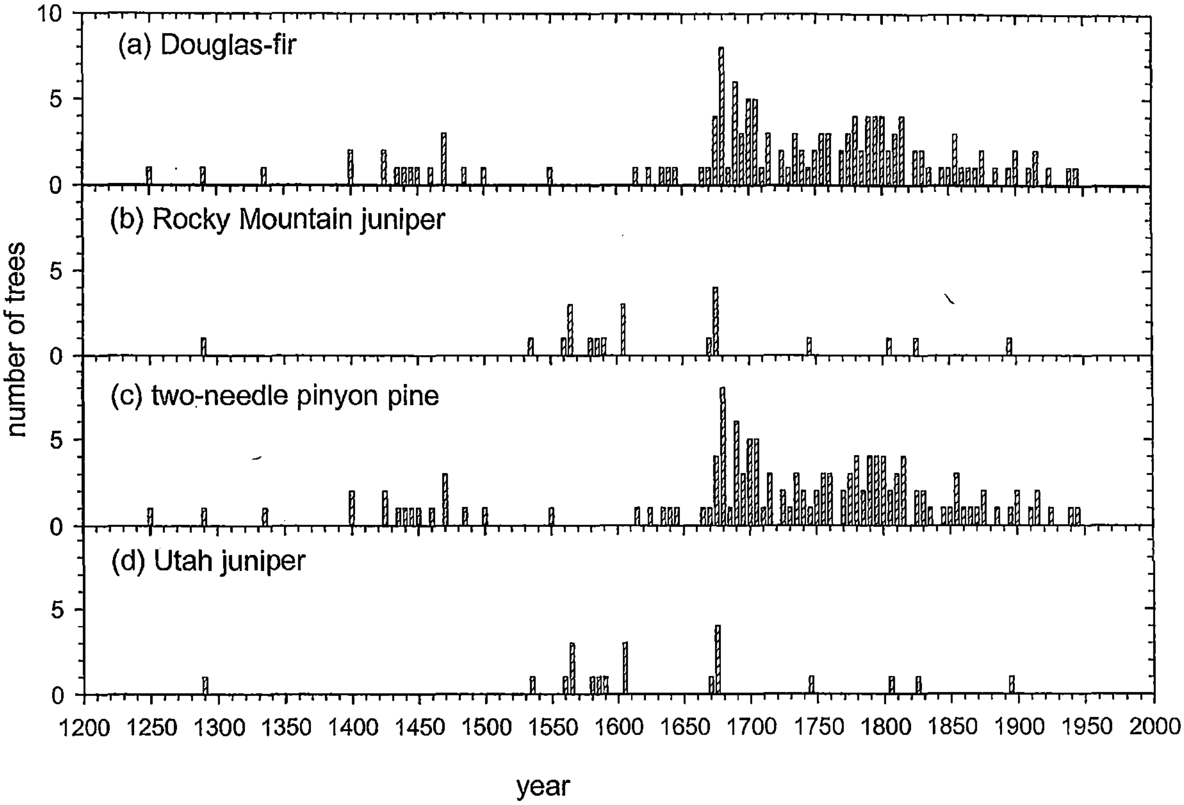


Figure 22. Distribution of tree-recruitment dates by species at BCL, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

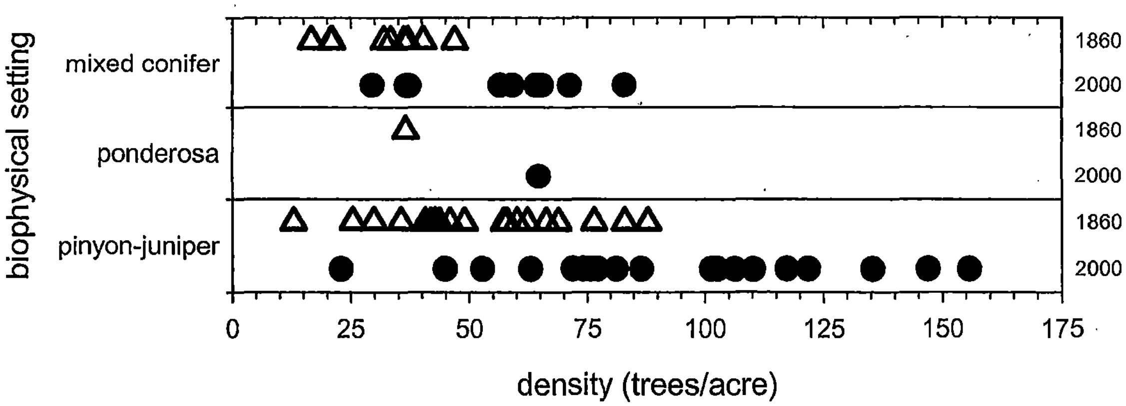


Figure 23. Density of live trees >8 inches DBH at each plot at BCL, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

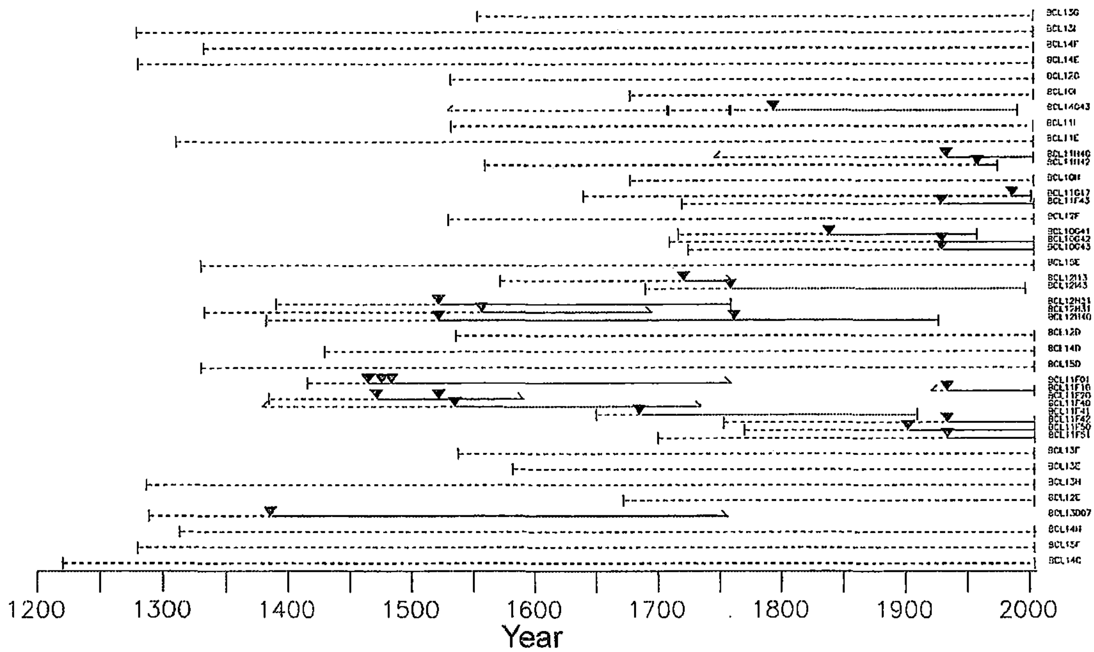
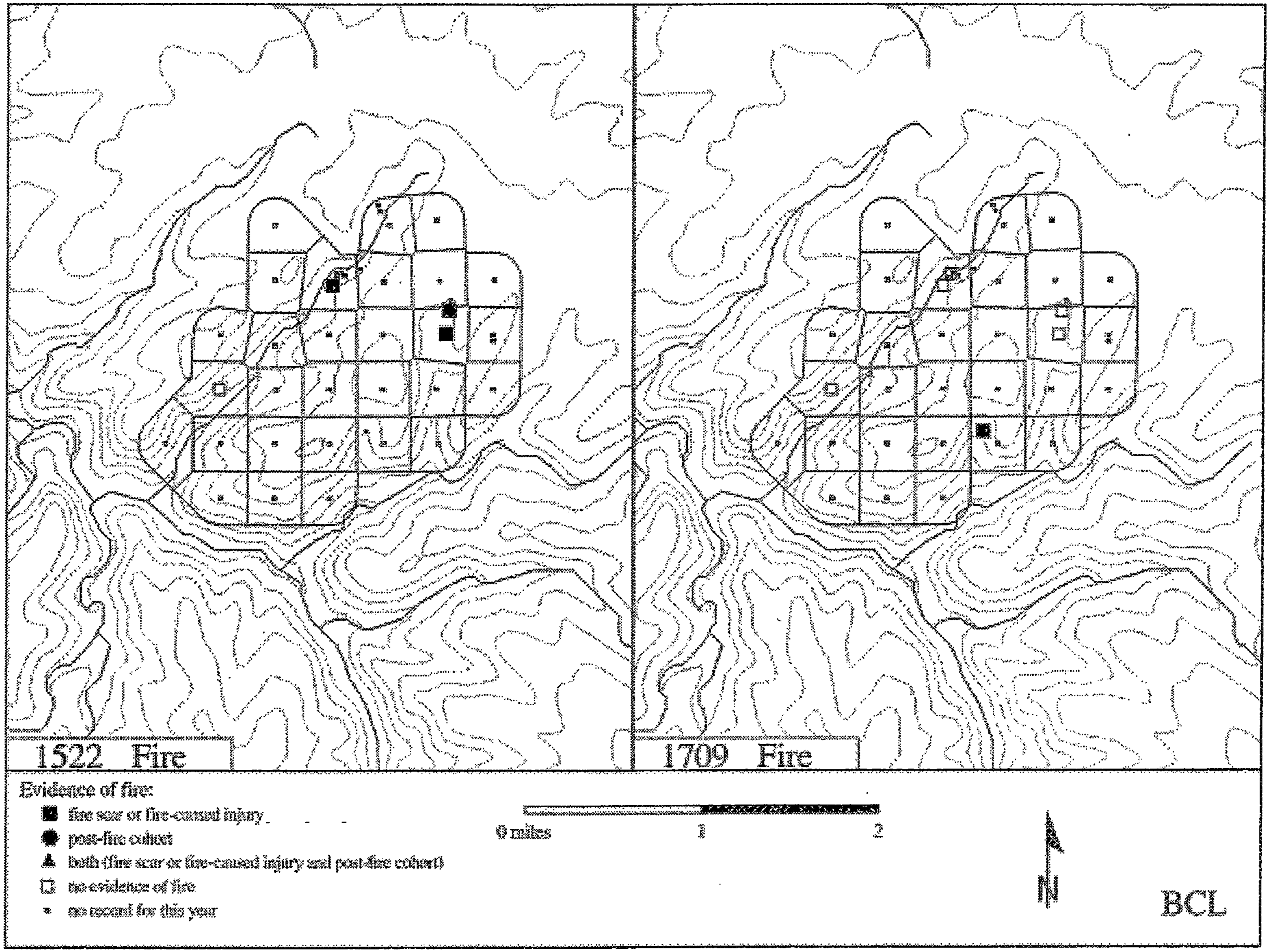
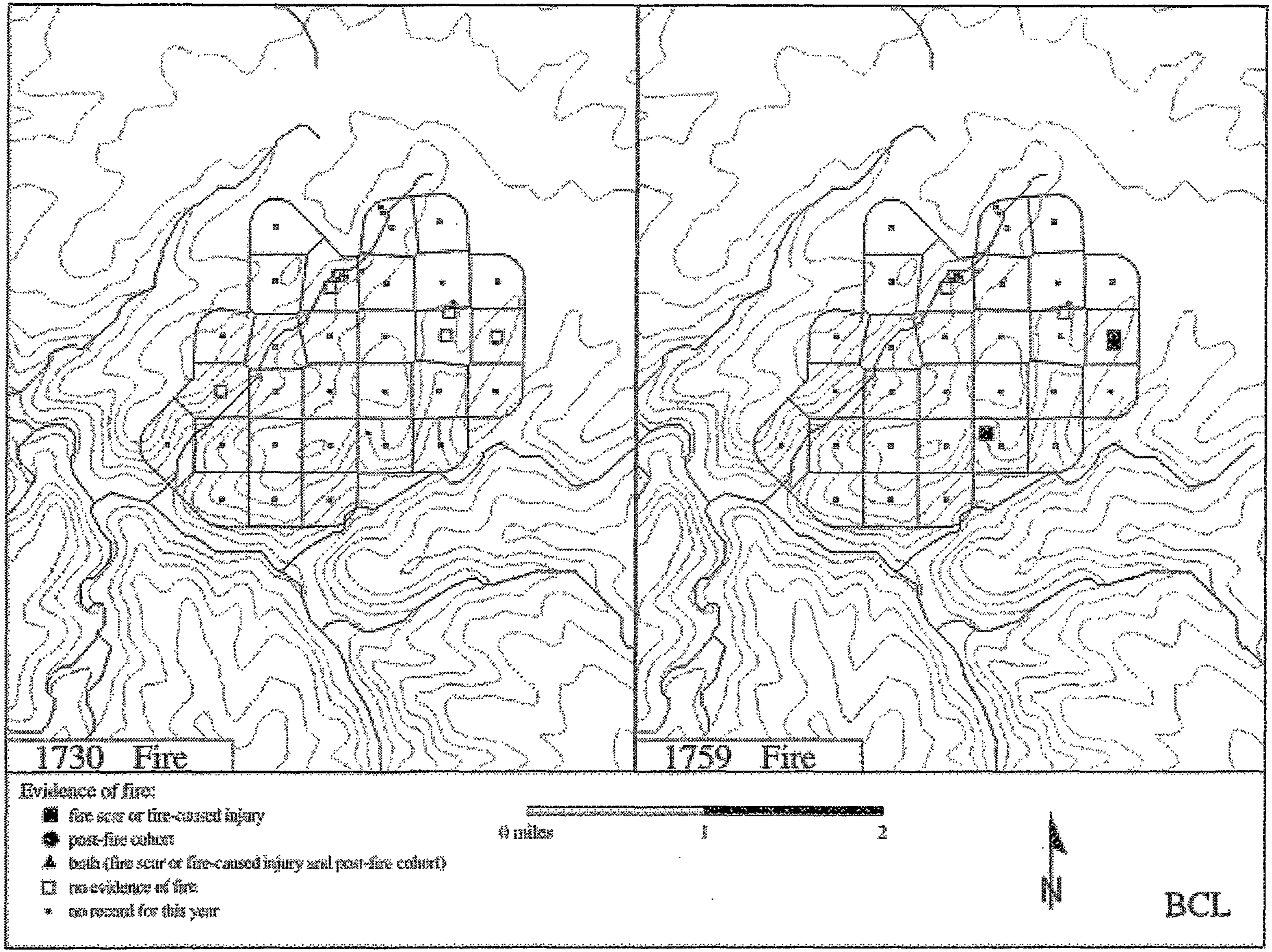


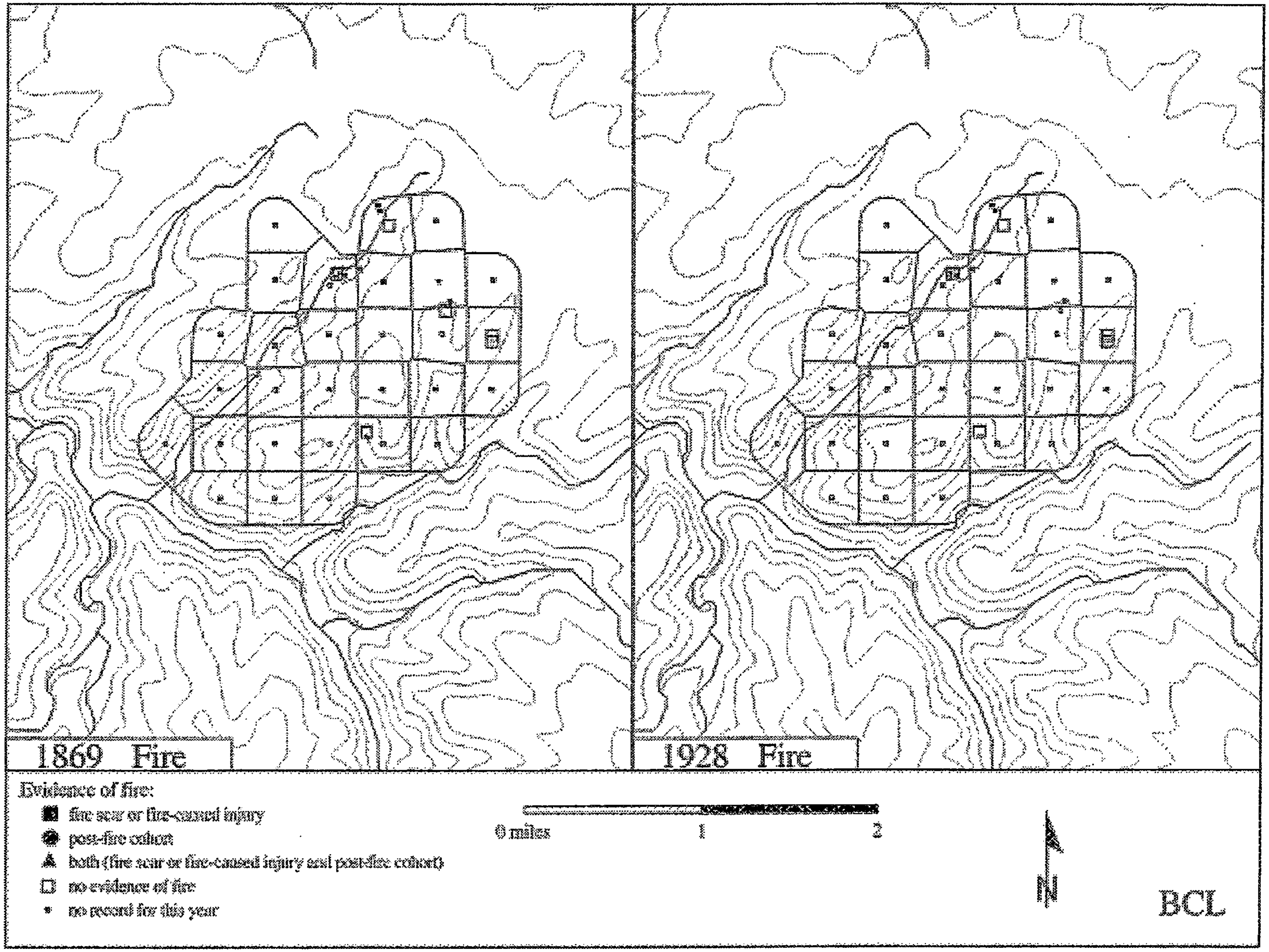
Figure 24. Fire chronologies at BCL, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

Maps of surface fires at BCL

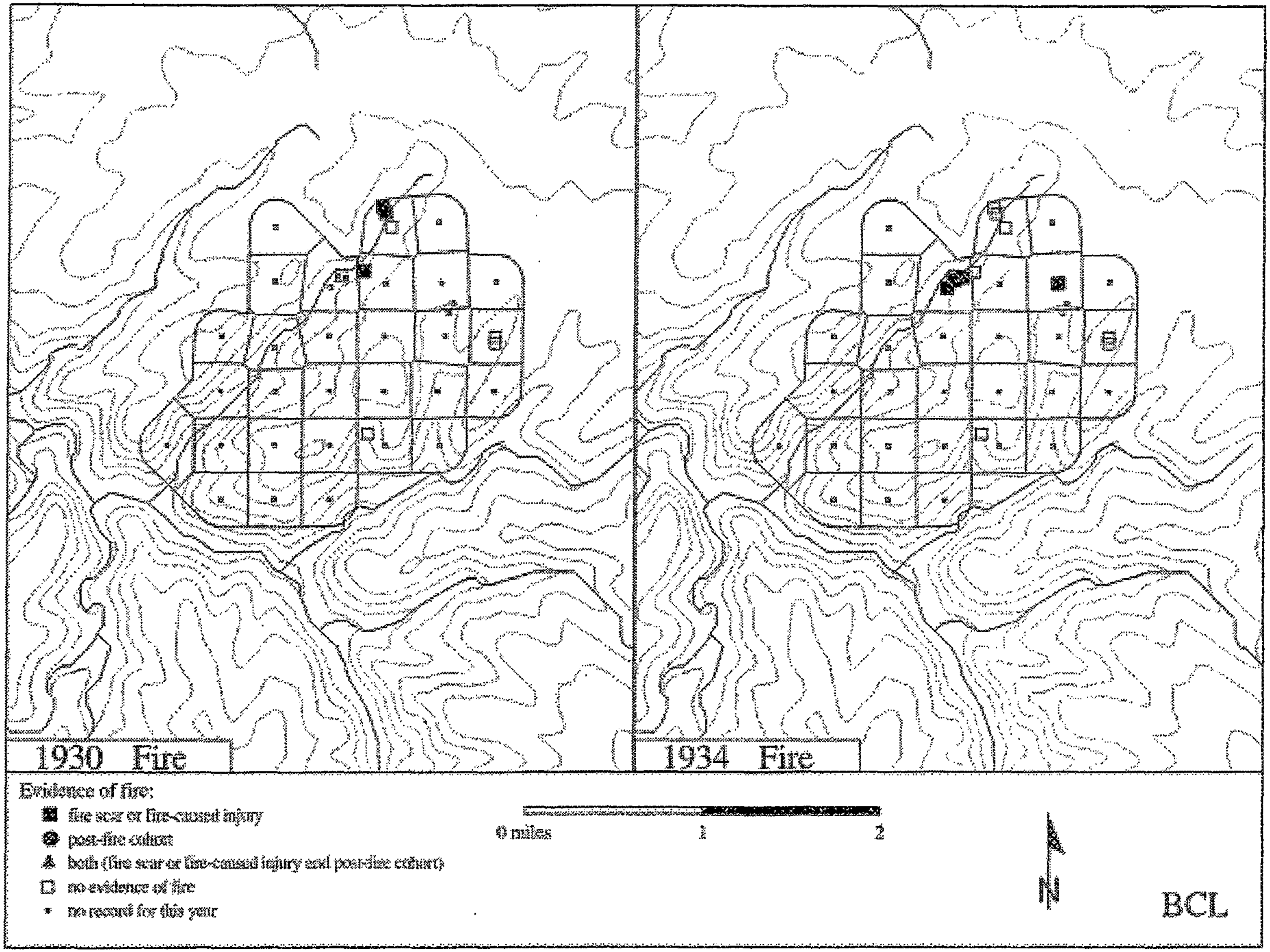
The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.

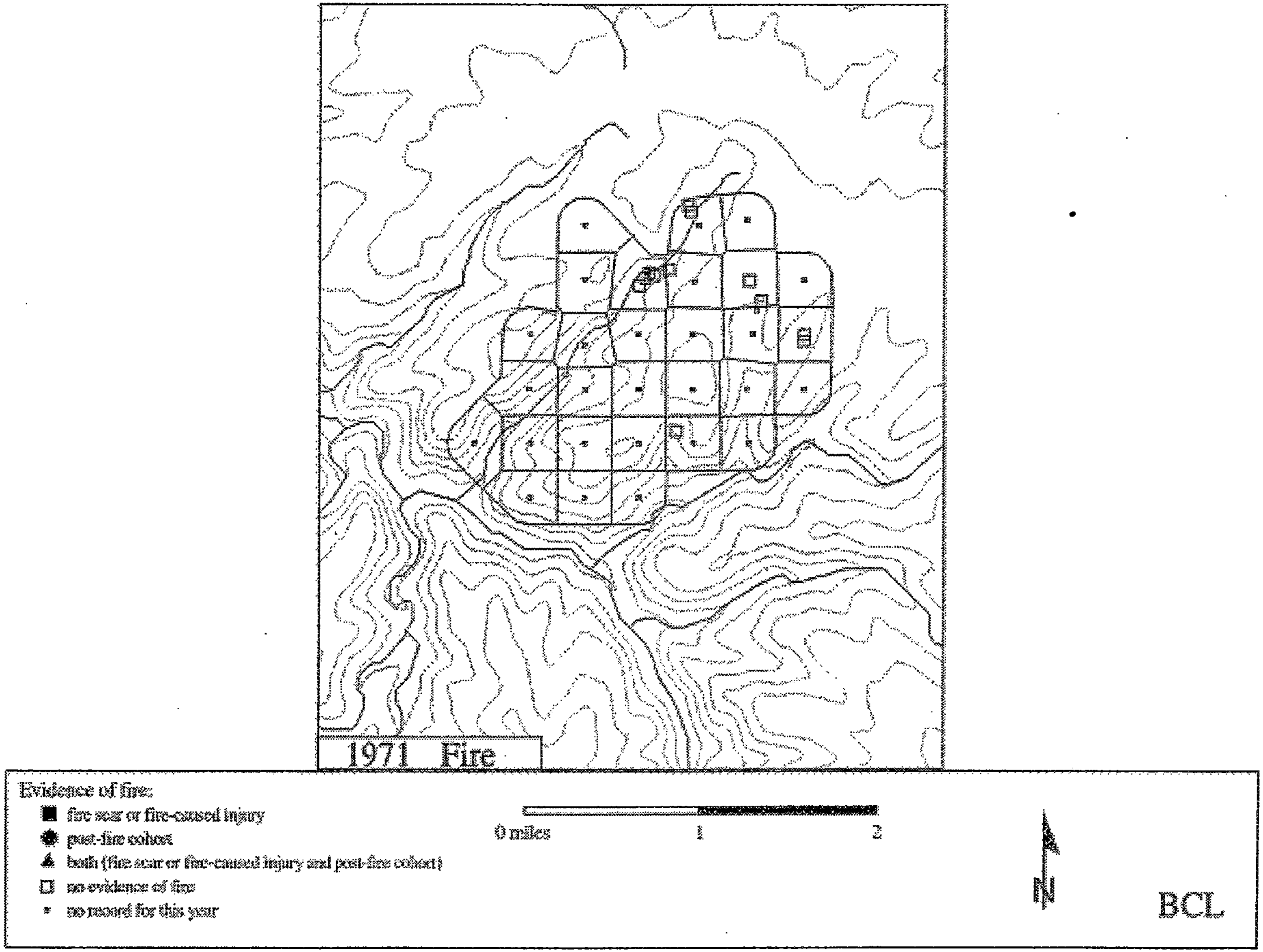

1522 Fire
1709 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BCL


1730 Fire
1759 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BCL



1869 Fire
1928 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BCL


1930 Fire
1934 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BCL


1971 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BCL

WASATCH RANGE - WASATCH-CACHE NATIONAL FOREST (WCH)

Study Area

We sampled a grid of 30 plots over 1612 acres near Peter Sinks, on the Logan Ranger District of the Wasatch-Cache National Forest in Cache county, Utah (Figure 25). The plots ranged in elevation from 7396 to 8487 feet, and in slope from 5 to 55%. The plots were sampled on a range of aspects (Figure 26). The topography of the plots we sampled was generally similar to that of the sampling area at this site.

Results

Tree recruitment

Our plots included 909 total trees (79% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 620 trees and were able to crossdate most of these (553 trees, or 89% of sampled trees). The trees that occurred on our plots included a range of species (Figure 27). Trees were recruited into the sampled plots between 1679 and 1959, although most trees (80%) were recruited after 1833 (Figure 28).

Average tree density was higher at plots in 2000 than in 1860 for all 4 of the forest types that we assigned to the sampled plots at this site (mixed conifer, aspen, lodgepole and spruce-fir, Figure 29, Table 2).

Surface fires

We removed fire-scarred sections from a total of 18 trees at WCH. We sampled all of these in the 5 of our 30 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were lodgepole pine (89%), with the rest Douglas-fir, and most were live (89%), but we also sampled some logs. We were unable to crossdate sections from some of the sampled trees (11%). Those that we did crossdate yielded 19 fire scars, and 1 injury (1679 to 2005; Figure 30). There were too few fire scars with a season (4 scars) during the analysis period (1650-1900) for us to determine the distribution of scars by intra-ring position at this site. There were not enough fire scars during the analysis period for us to determine the number of fires by elevation or forest type.

Figures and tables for WCH

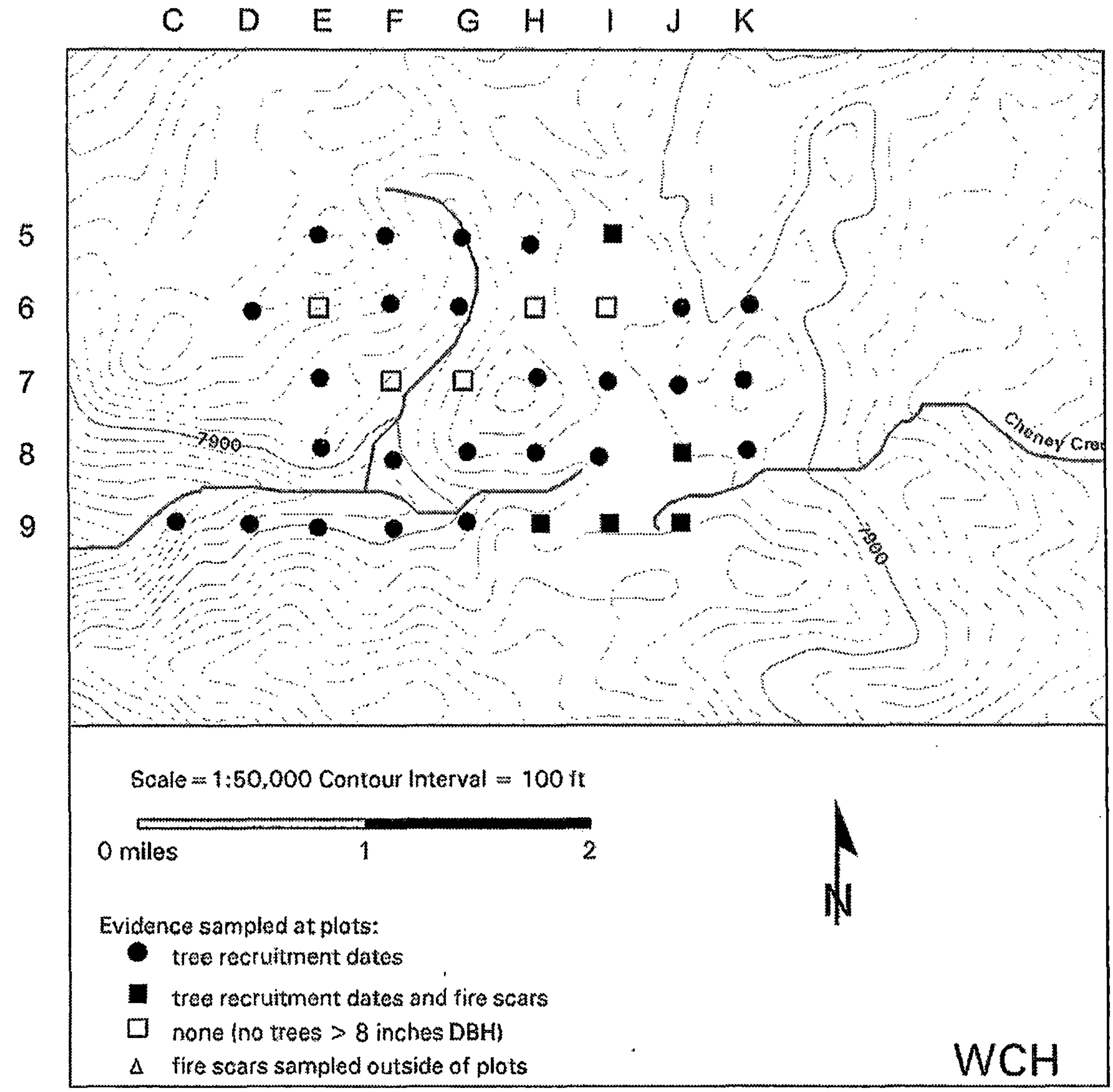


Figure 25. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the northwestern most plot is 5E, the next plot to the east is 5F, etc. All of the fire-scarred trees that we date (16 trees) were sampled within plots and so are not mapped individually.

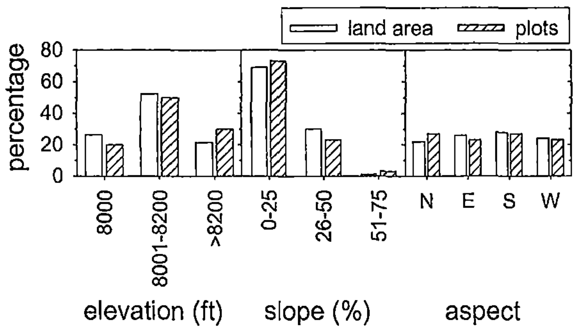


Figure 26. Distribution of topography for sampled plots and for land area at WCH. Aspect classes are 90° wide, beginning with 46° for east (E). Land area was derived from a digital elevation model.

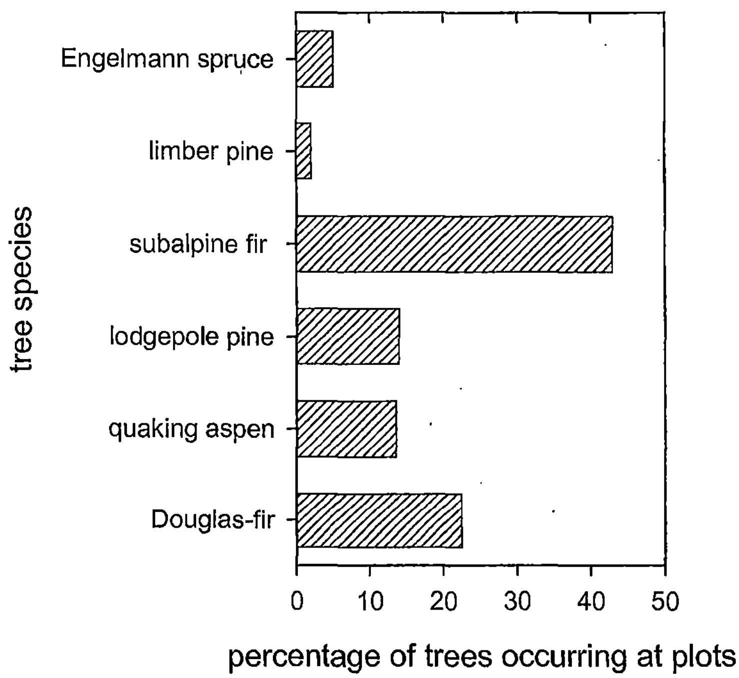


Figure 27. Species distribution of all trees that occurred in plots at WCH.

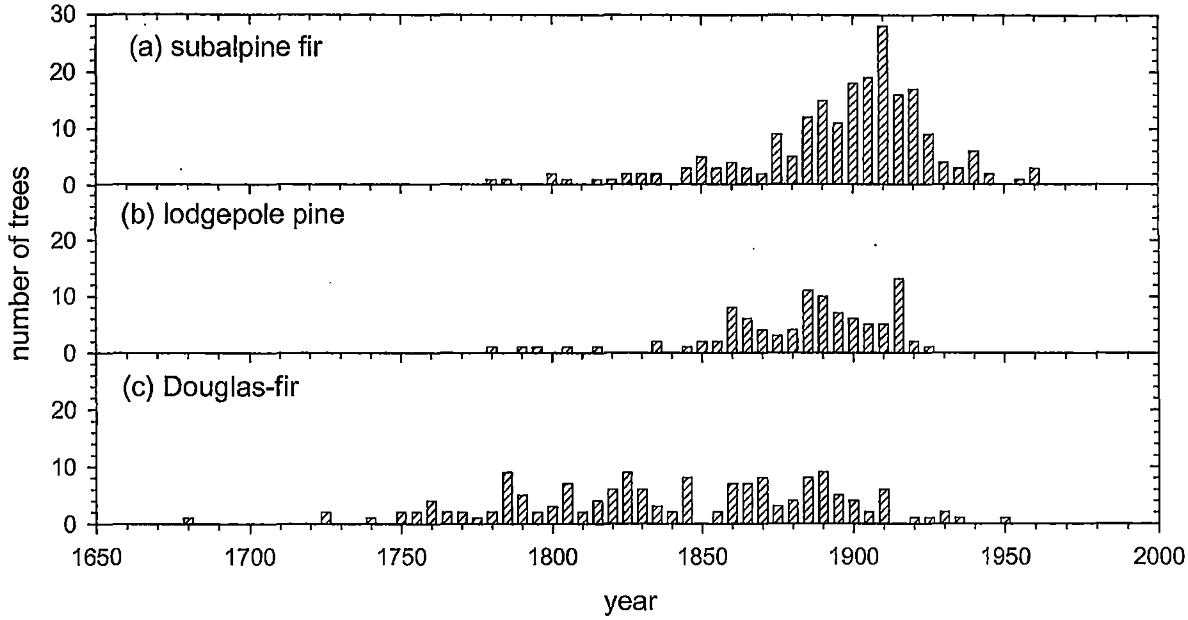


Figure 28. Distribution of tree-recruitment dates by species at WCH, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

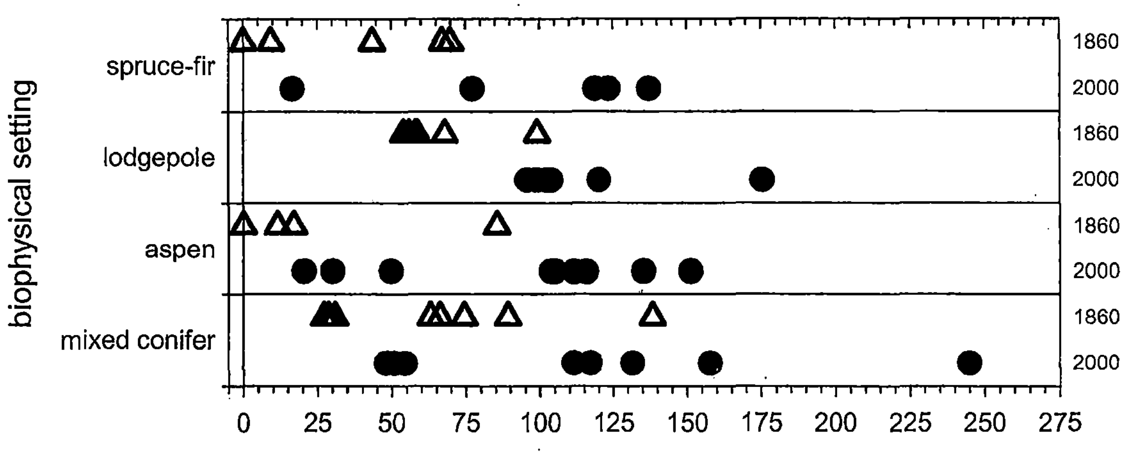


Figure 29. Density of live trees >8 inches DBH at each plot at WCH, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

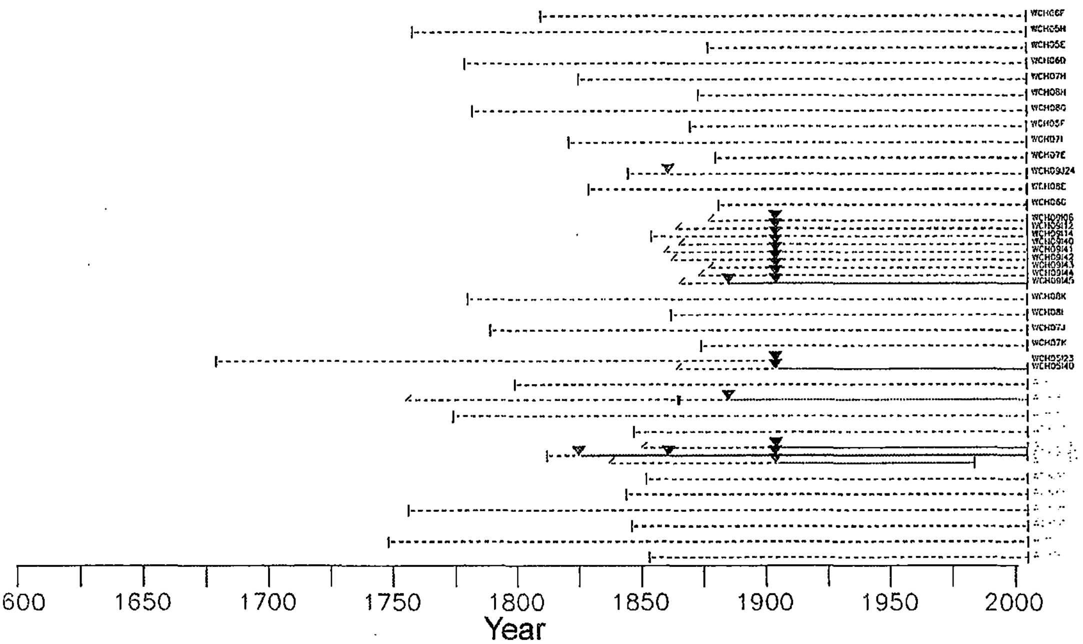
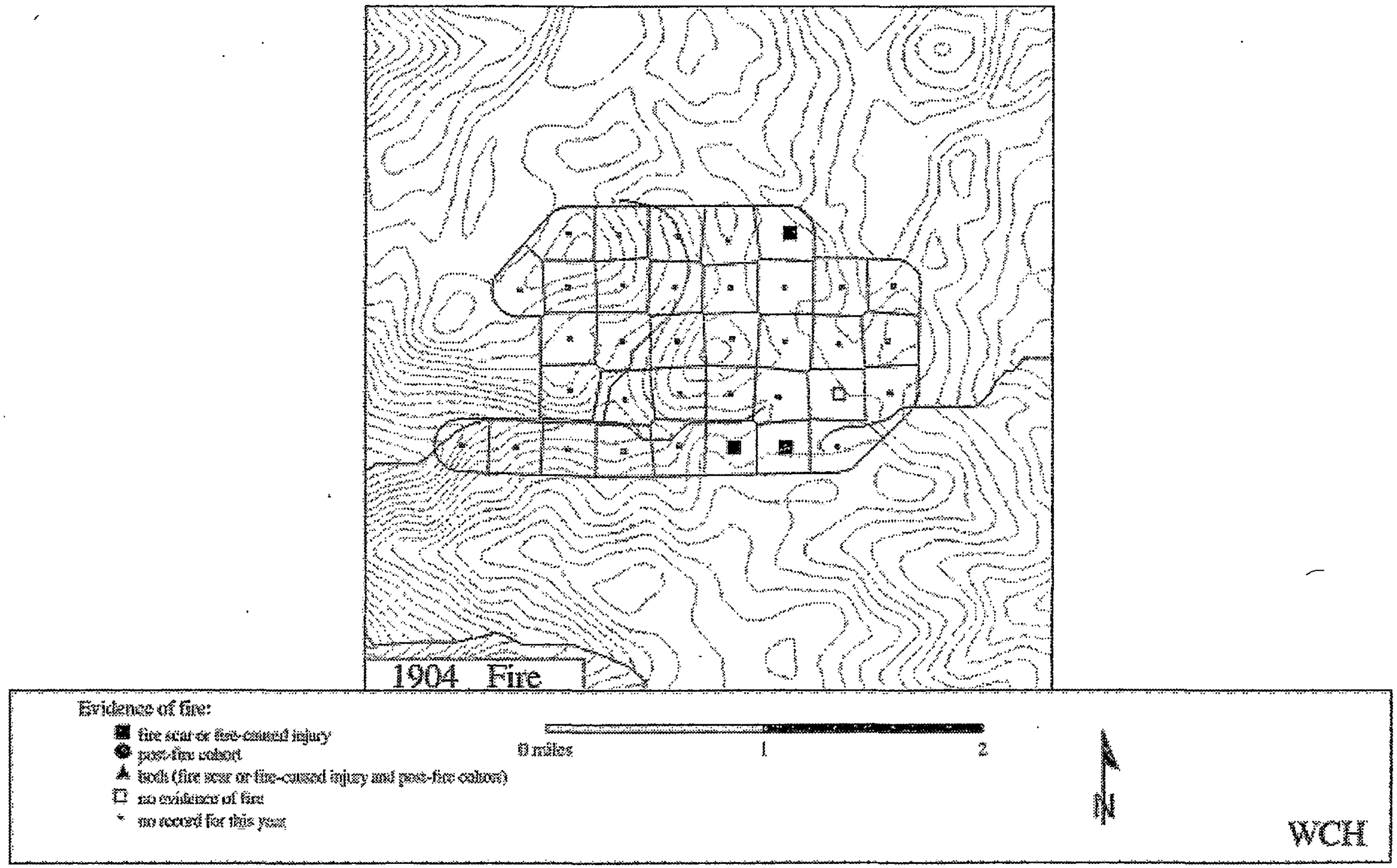


Figure 30. Fire chronologies at WCH, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

Maps of surface fires at WCH

The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.


1904 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WCH

WESTERN UINTAH MOUNTAINS - ASHLEY NATIONAL FOREST (WUN)

Study Area

We sampled a grid of 25 plots over 1760 acres in Miners Gulch, on the Duchesne Ranger District of the Ashley National Forest in Duchesne county, Utah (Figure 31). The plots ranged in elevation from 7357 to 10444 feet, and in slope from 5 to 65%. The plots were sampled on a range of aspects, although most plots were on south or east aspects (88%). The topography of the plots we sampled was generally similar to that of the sampling area at this site (Figure 32).

Results

Tree recruitment

Our plots included 745 total trees (84% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 634 trees and were able to crossdate most of these (524 trees, or 83% of sampled trees). The trees that occurred on our plots included a range of species (Figure 33). Trees were recruited into the sampled plots between 1614 and 1961, although most trees (80%) were recruited after 1812 (Figure 34).

Average tree density was higher at plots in 2000 than in 1860 for all 4 of the forest types that we assigned to the sampled plots at this site (ponderosa, mixed conifer, lodgepole and spruce-fir, Figure 35, Table 2).

Surface fires

We removed fire-scarred sections from a total of 76 trees at WUN. We sampled most of these (84%) in the 18 of our 25 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were lodgepole pine (51%), ponderosa pine (32%) or Douglas-fir (14%), but we also sampled a few fire-scarred subalpine fir and Rocky Mountain juniper. About half of the trees we sampled were logs and snags (46%), with the rest live trees. We were unable to crossdate sections from some of the sampled trees (12%). Those that we did crossdate yielded 95 fire scars, and 32 eroded fire scars or abrupt changes in ring width (1533 to 2004; Figure 36). We were able to assign an intra-ring position to 57% of the fire scars. Most of the scars from the analysis period (1650-1900) were created by fires burning early in the cambial growing season, or when the cambium was dormant (82% of assigned scars), although the distribution varied among species at this site (Figure 37).

The number of surface fires during the analysis period (1650-1900) did not vary substantially with elevation or forest type at WUN (Figure 38). We found little evidence of surface fires after ≈1900 at this site (Figure 36).

Figures and tables for WUN

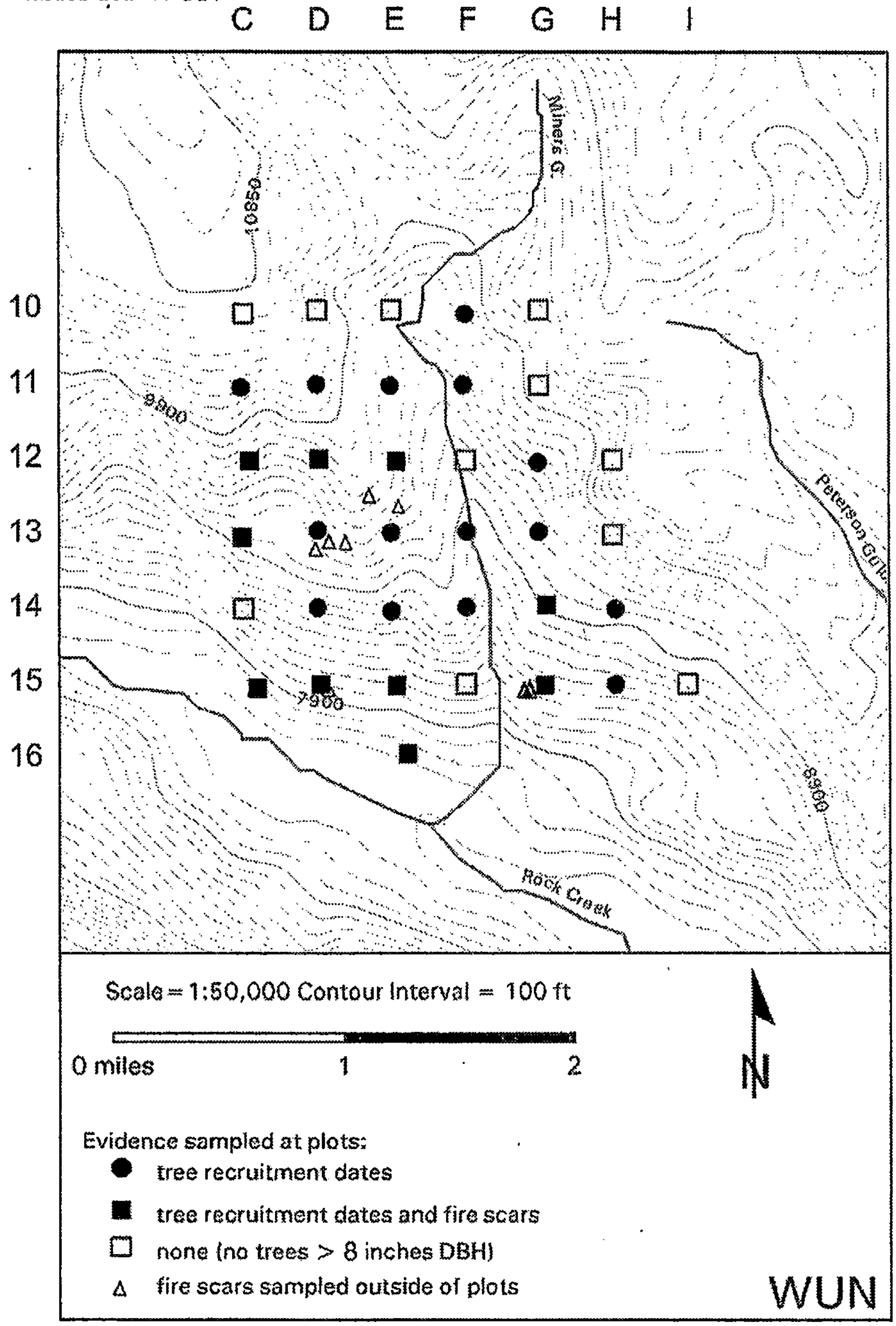


Figure 31. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the northwestern most plot is 10C, the next plot to the east is 10D, etc. Most of the fire-scarred trees (84% of 67 dated trees) were sampled within plots and so are not mapped individually.

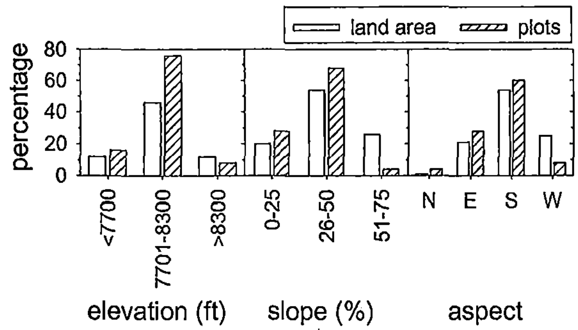


Figure 32. Distribution of topography for sampled plots and for land area at WUN. Aspect classes are 90° wide, beginning with 46° for east (E). Land area was derived from a digital elevation model.

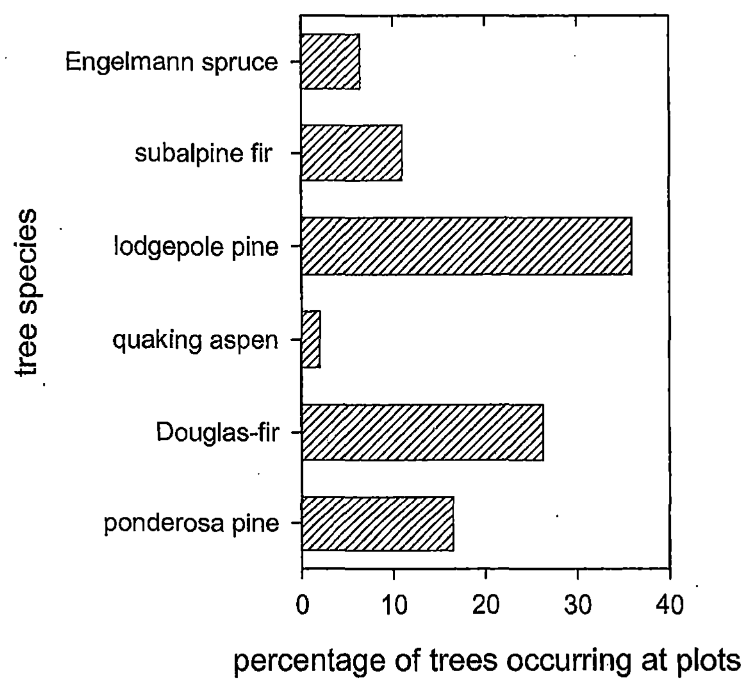


Figure 33. Species distribution of all trees that occurred in plots at WUN. In addition, 7 Rocky Mountain juniper and 1 two-needle pinyon trees occurred in our plots but are not shown.

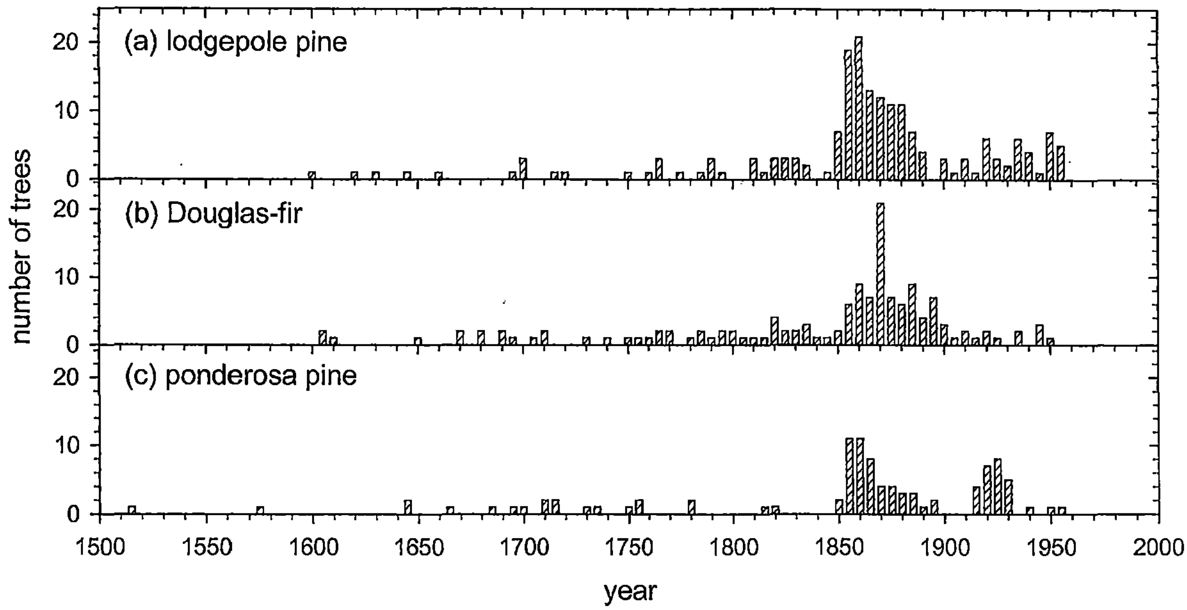


Figure 34. Distribution of tree-recruitment dates by species at WUN, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

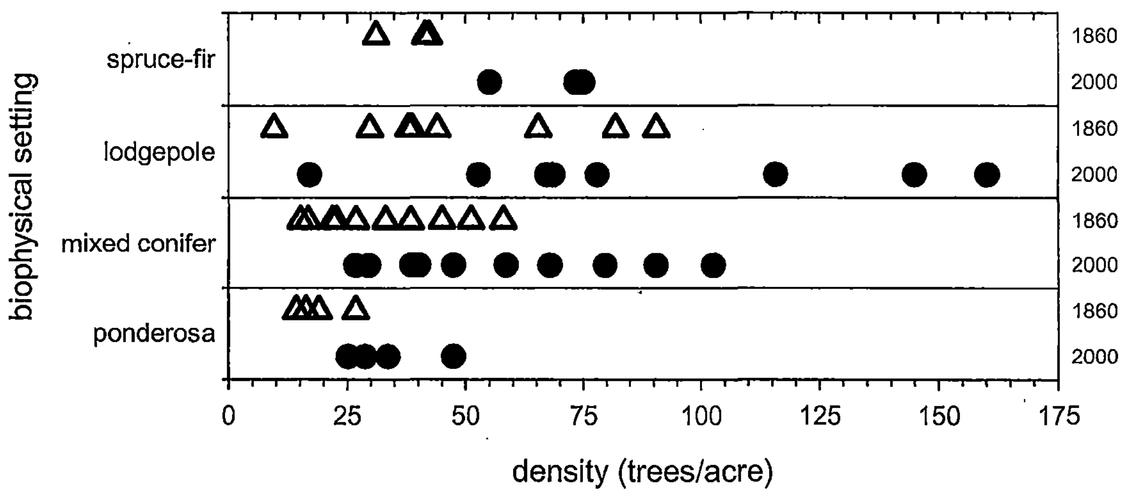


Figure 35. Density of live trees >8 inches DBH at each plot at WUN, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

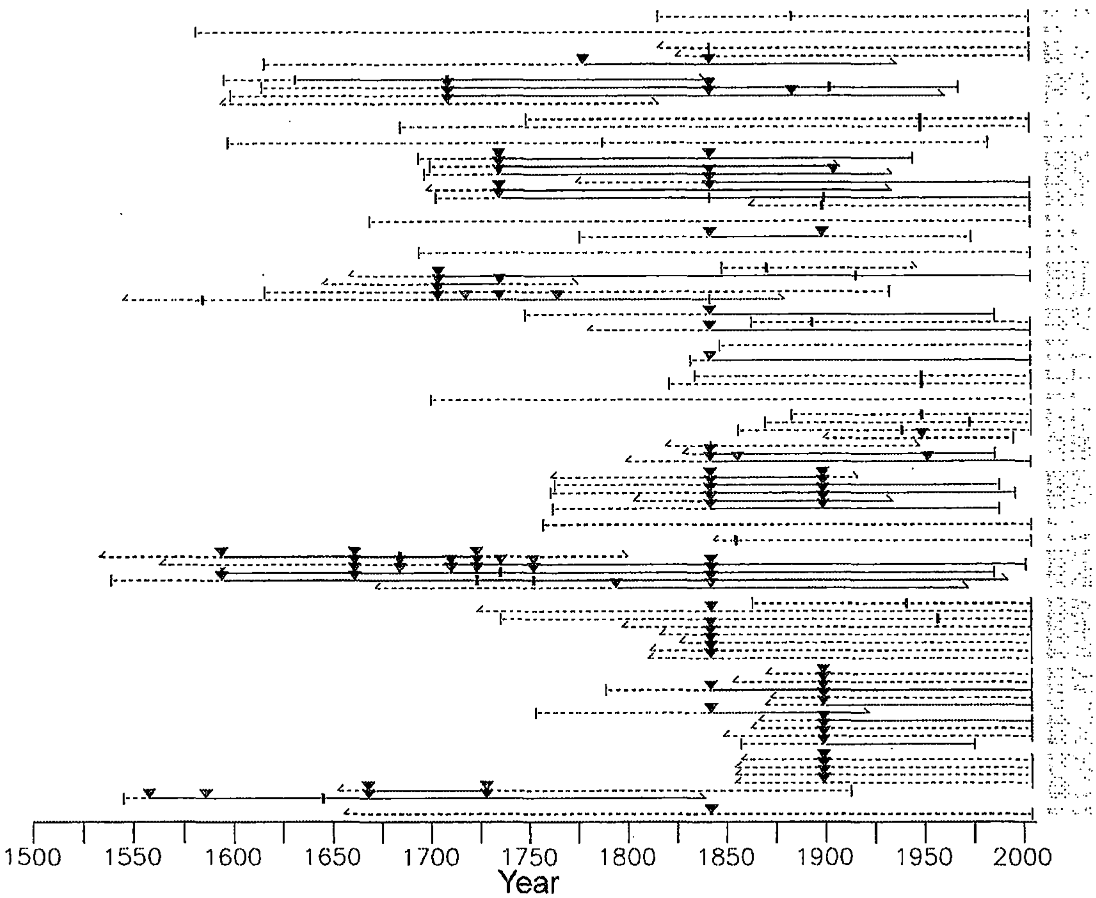


Figure 36. Fire chronologies at WUN, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

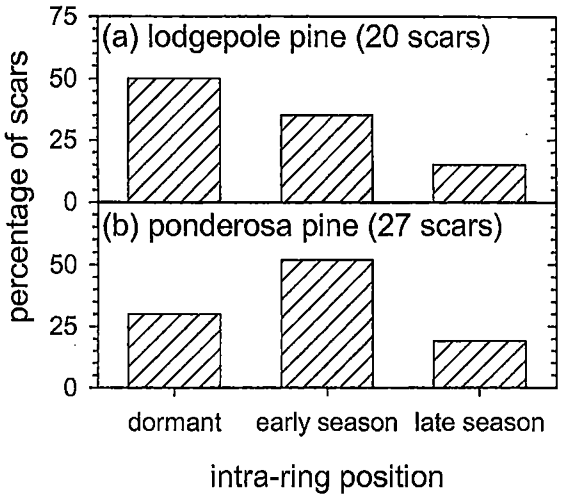


Figure 37. Intra-ring position of fire scars at WUN (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only species that comprised >10% of trees are plotted. We also dated scars from some Douglas-fir, subalpine fir and Rocky Mountain juniper, but these species yielded too few scars with an intra-ring position to plot here.

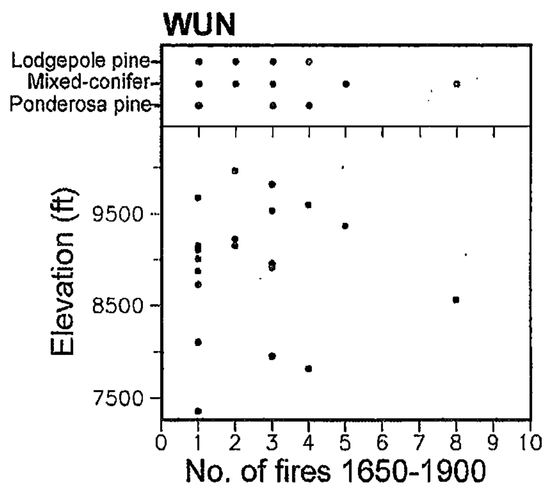
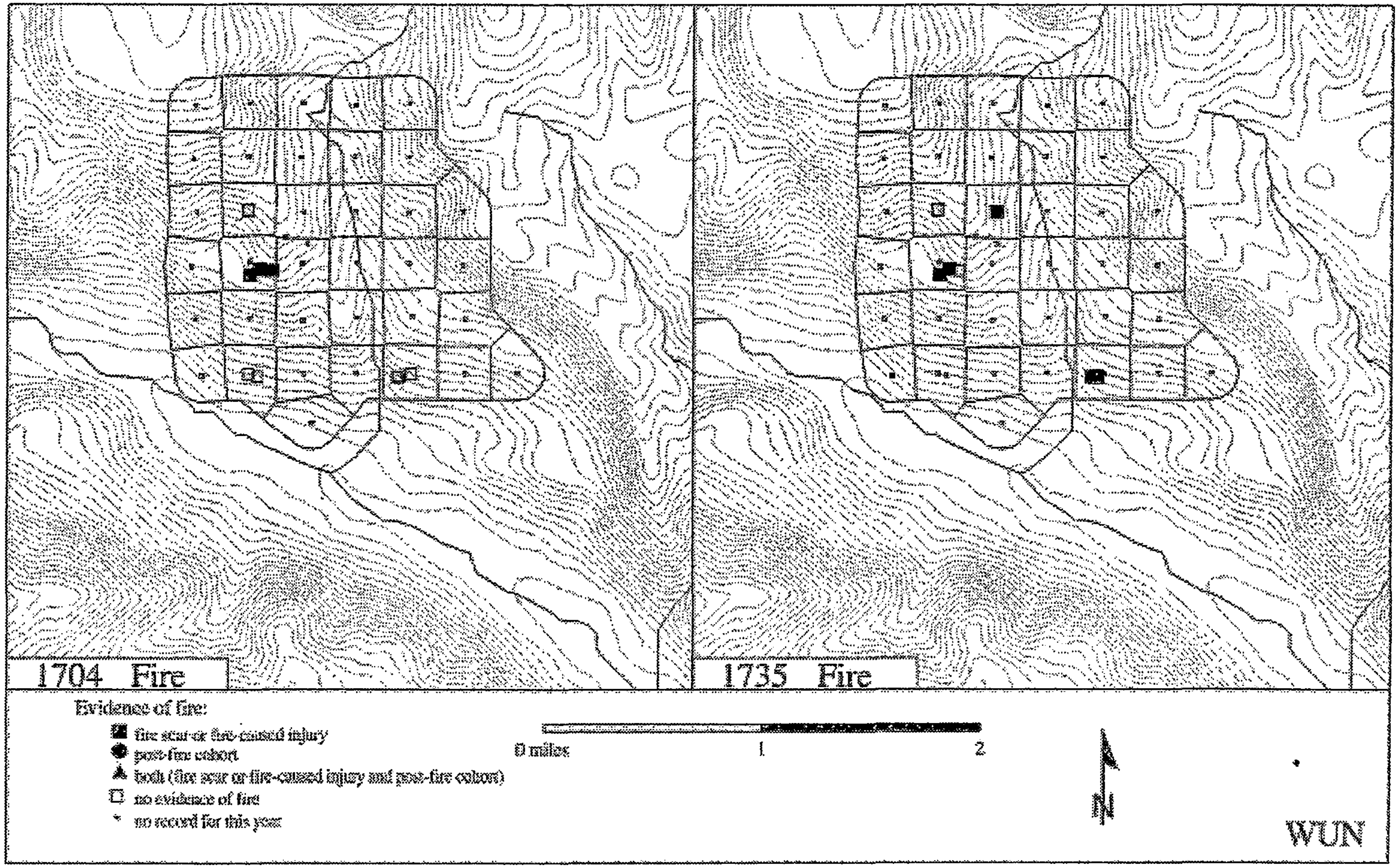
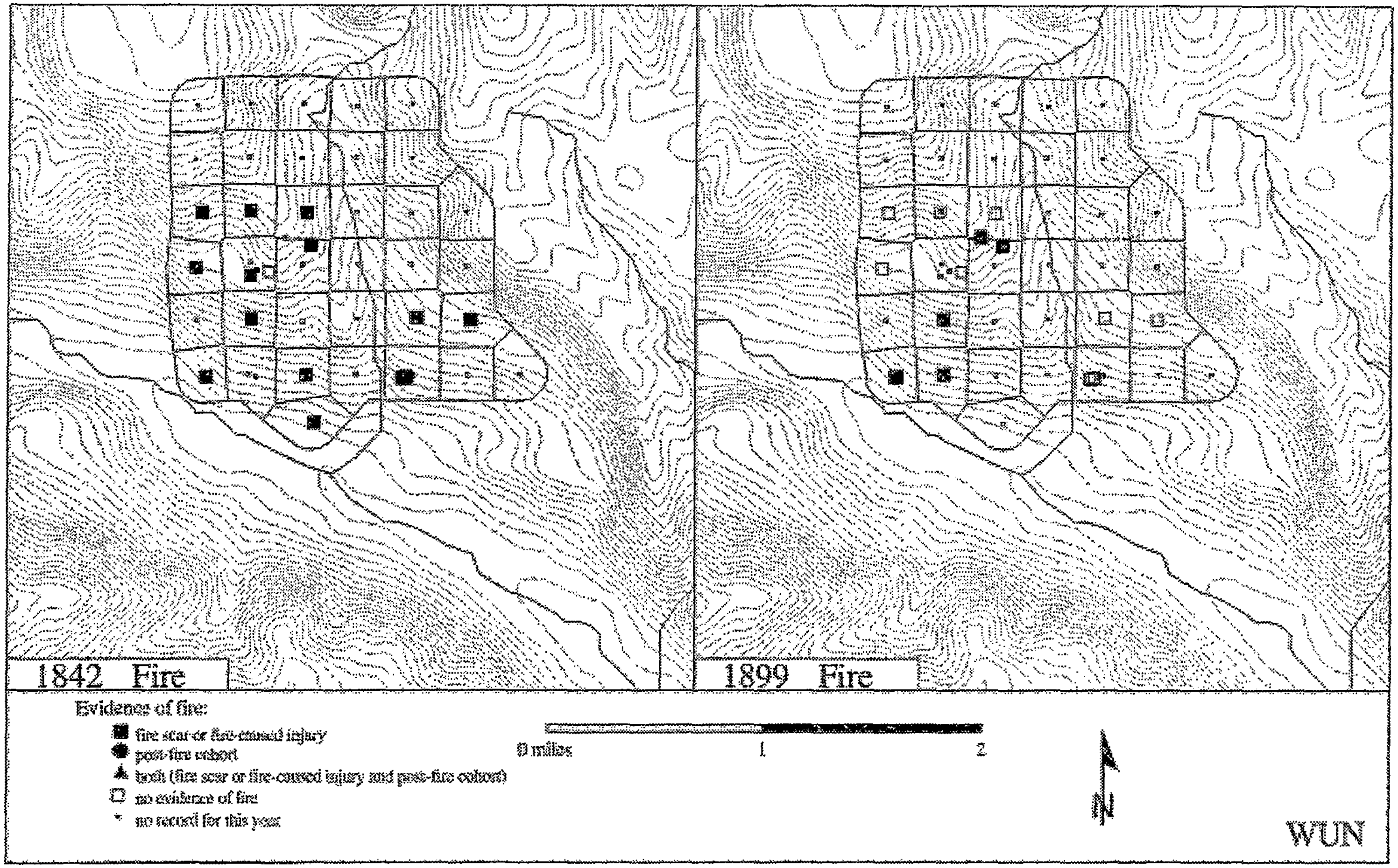


Figure 38. Number of fires within cells at WUN (1650-1900), by forest type (top panel, Table 2) and elevation (bottom panel). Number of fires includes only those fire years which were recorded on ≥2 trees at a site.

Maps of surface fires at WUN

The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.


1704 Fire
1735 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WUN


1842 Fire
1899 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
WUN

CENTRAL UINTAH MOUNTAINS - ASHLEY NATIONAL FOREST (MUR)

Study Area

We sampled a grid of 30 plots over 1441 acres near Pole and Big Bend Creeks, on the Roosevelt Ranger District of the Ashley National Forest in Duchesne county, Utah (Figure 39). The plots ranged in elevation from 7570 to 10660 feet, and in slope from 0 to 68%. The plots were sampled on a range of aspects, although we did not sample any plots on north aspects (Figure 40). The topography of the plots we sampled was generally similar to that of the sampling area at this site.

Results

Tree recruitment

Our plots included 810 total trees (73% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 765 trees and were able to crossdate most of these (610 trees, or 80% of sampled trees). The trees that occurred on our plots included a range of species (Figure 41). Trees were recruited into the sampled plots between 1410 and 1974, although most trees (80%) were recruited after 1801 (Figure 42).

Average tree density was higher at plots in 2000 than in 1860 for all 5 of the forest types that we assigned to the sampled plots at this site (ponderosa, aspen-mixed conifer, aspen, lodgepole and spruce-fir, Figure 43, Table 2).

Surface fires

We removed fire-scarred sections from a total of 97 trees at MUR. We sampled more than half of these (57%) in the 16 of our 30 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were lodgepole pine (40%), ponderosa pine (39%) or Engelmann spruce (18%), but we also sampled a few white fir. Most of the trees we sampled were logs, snags or stumps (67%), with the rest live trees. We were unable to crossdate sections from some of the sampled trees (13%). Those that we did crossdate yielded 169 fire scars, and 9 eroded fire scars or abrupt changes in ring width (1545 to 2005; Figure 44). We were able to assign an intra-ring position to 66% of the fire scars. Most of the scars from the analysis period (1650-1900) were created by fires burning late in the cambial growing season or when the cambium was dormant (85% of assigned scars, Figure 45).

The number of surface fires during the analysis period (1650-1900) varied with elevation and forest type at MUR (Figure 46), with fires more frequent at low than high elevation, and in dry versus mesic forest types. We found little evidence of surface fires after ≈1900 at this site.

Figures and tables for MUR

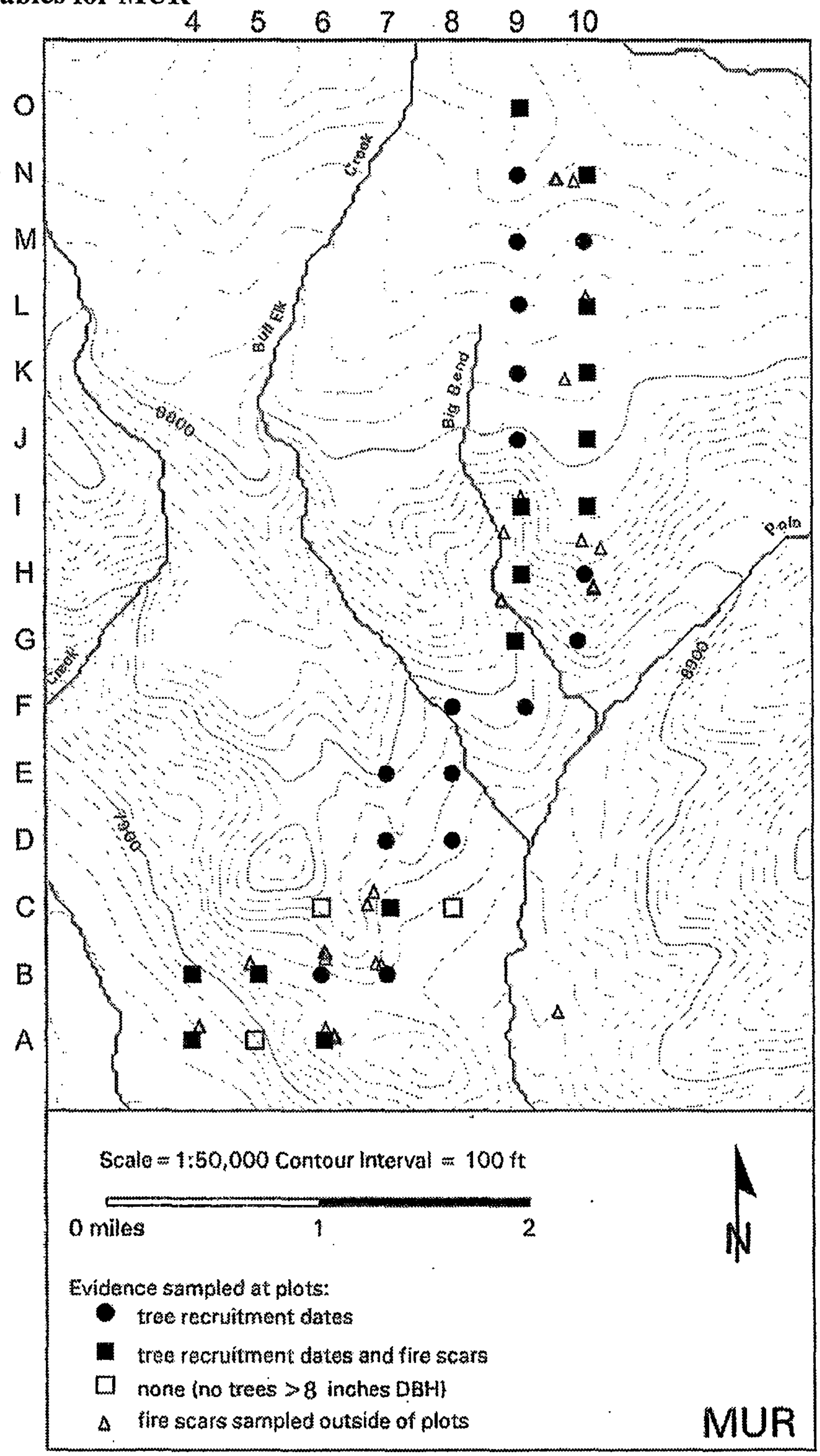


Figure 39. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the southwestern most plot is 4A, the next plot to the east is 5A, etc., but note that the order of the column and row identifiers at this site differs from that at most other sites. Most of the fire-scarred trees (57% of 84 dated trees) were sampled within plots and so are not mapped individually.

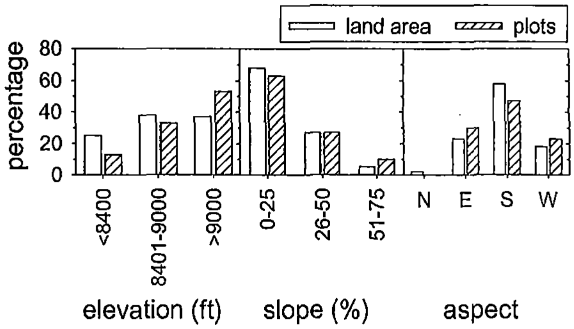


Figure 40. Distribution of topography for sampled plots and for land area at MUR. Aspect classes are 90° wide, beginning with 46° for east (E). Land area was derived from a digital elevation model.

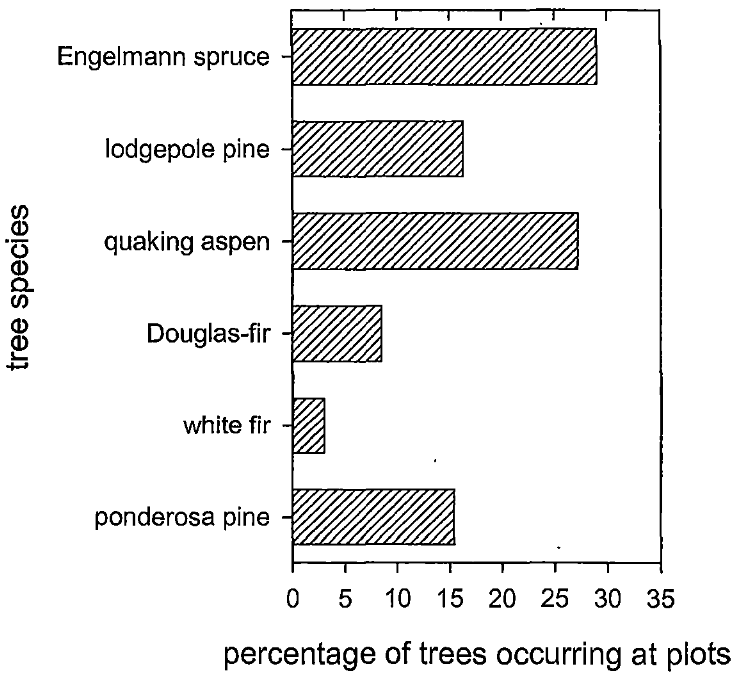


Figure 41. Species distribution of all trees that occurred in plots at MUR. In addition, 8 Utah juniper trees occurred in our plots but are not shown.

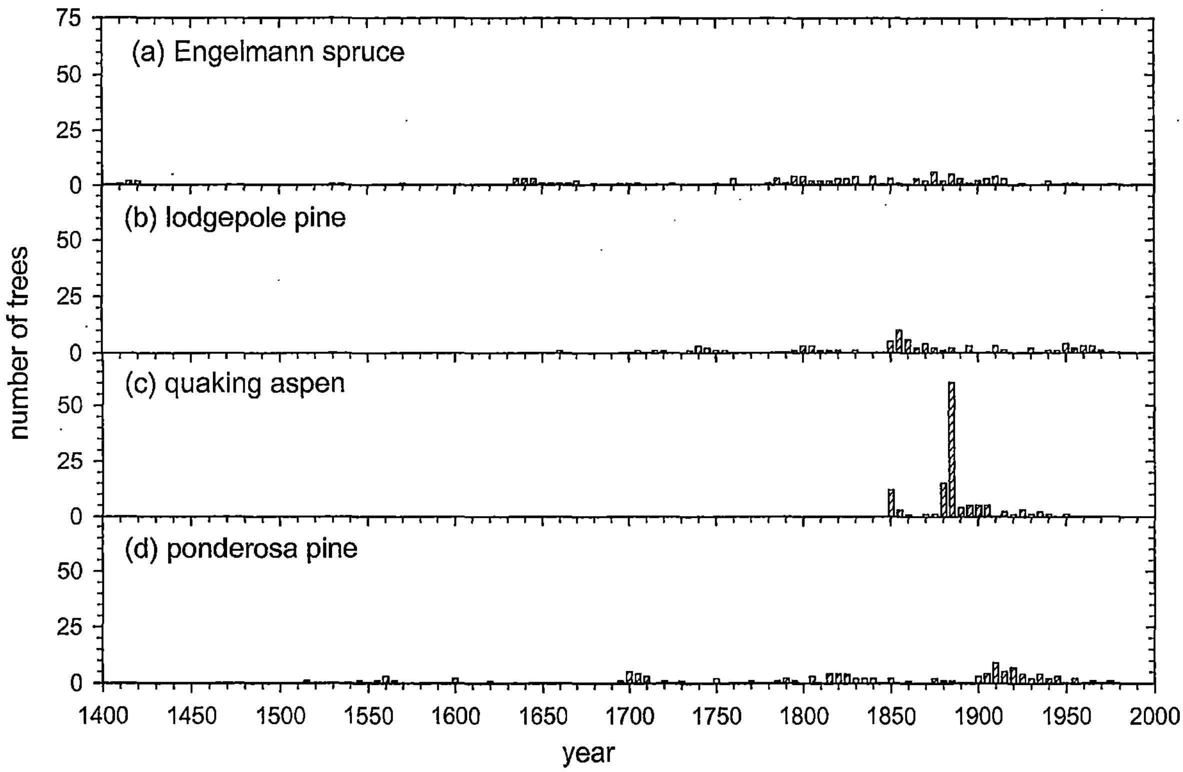


Figure 42. Distribution of tree-recruitment dates by species at MUR, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

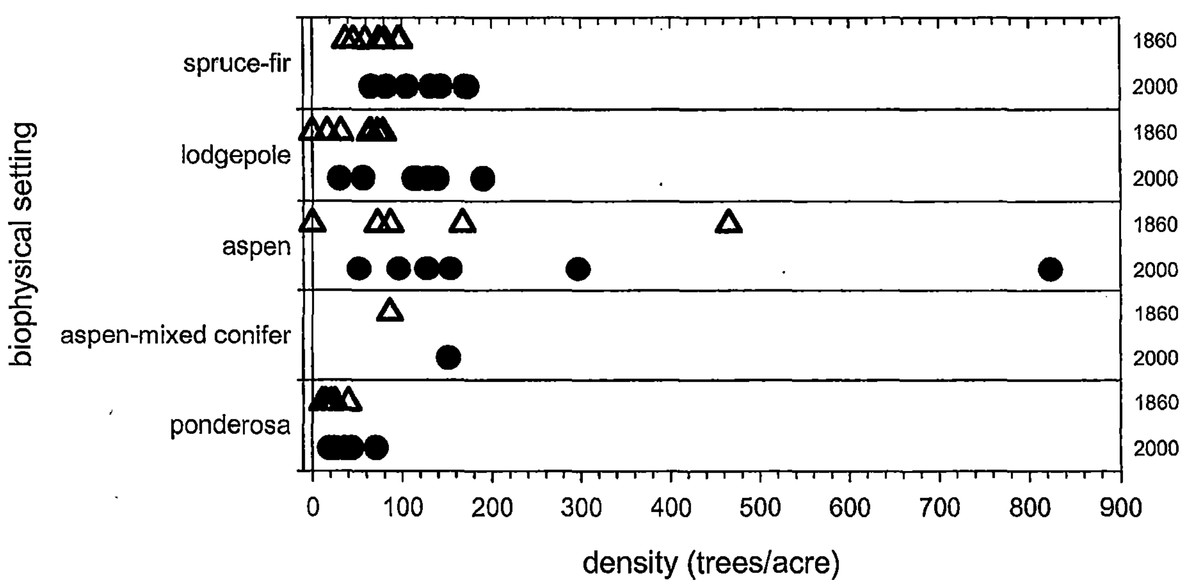


Figure 43. Density of live trees >8 inches DBH at each plot at MUR, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

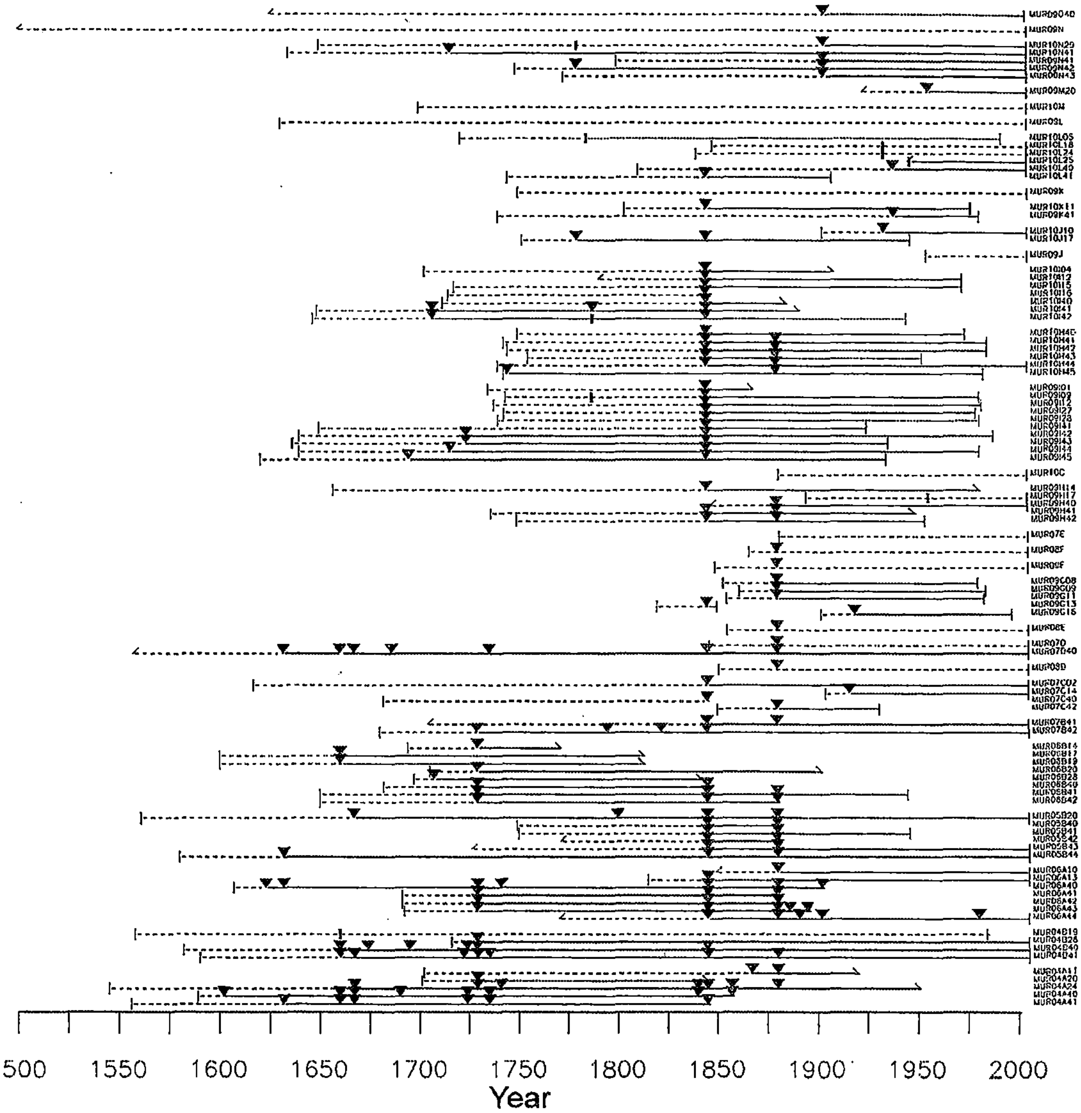


Figure 44. Fire chronologies at MUR, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

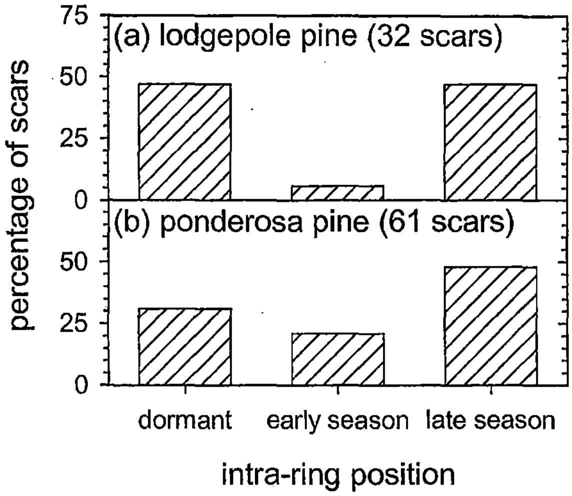


Figure 45. Intra-ring position of fire scars at MUR (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only species that comprised >10% of trees are plotted. We also dated scars from some Douglas-fir, white fir and Engelmann spruce, but these species yielded too few scars with an intra-ring position to plot here.

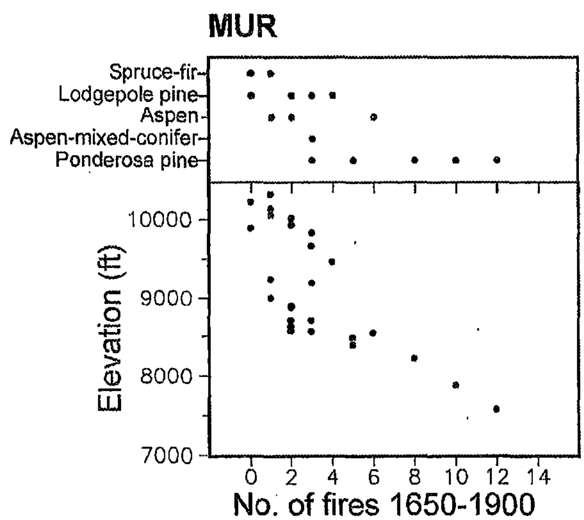
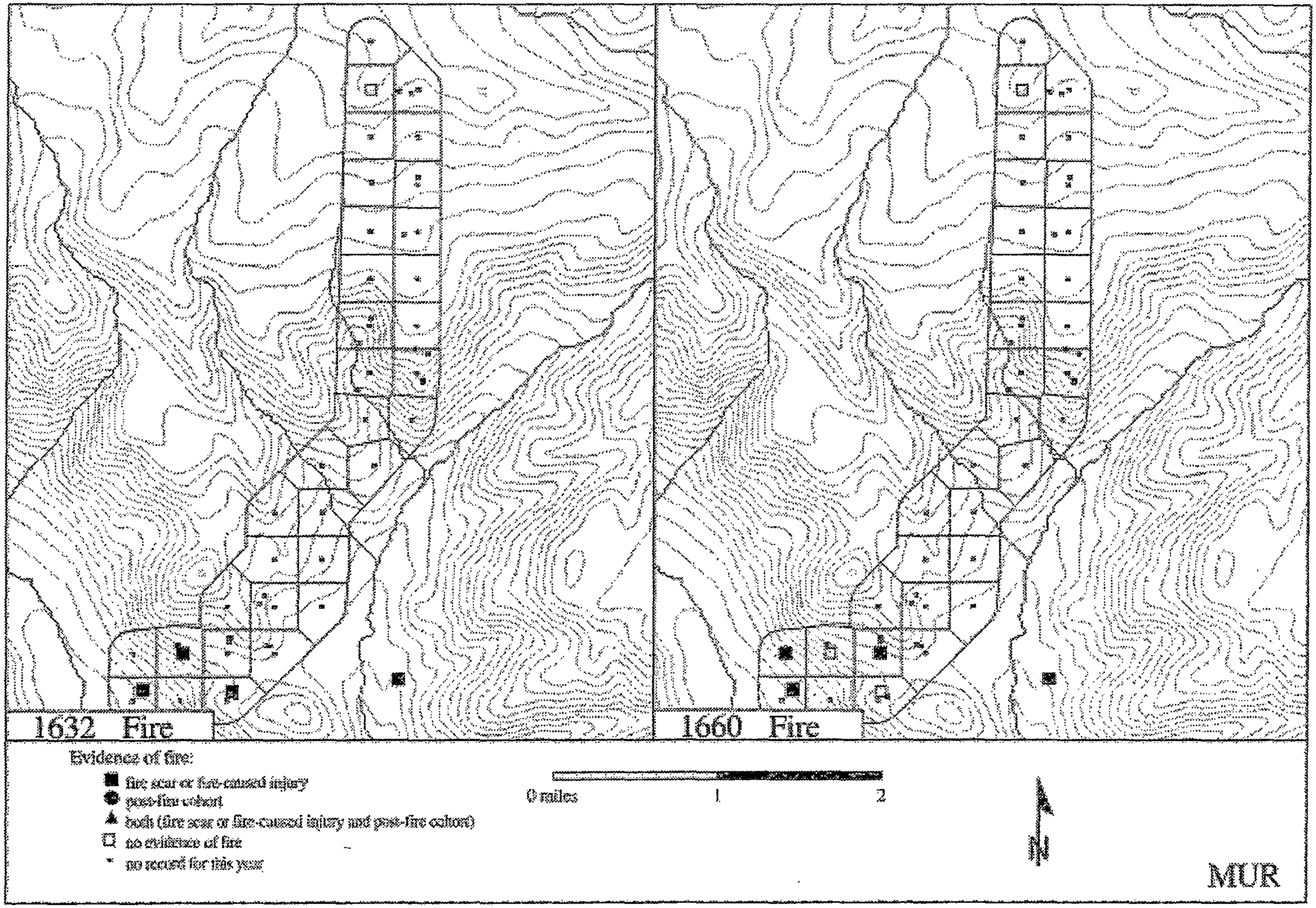
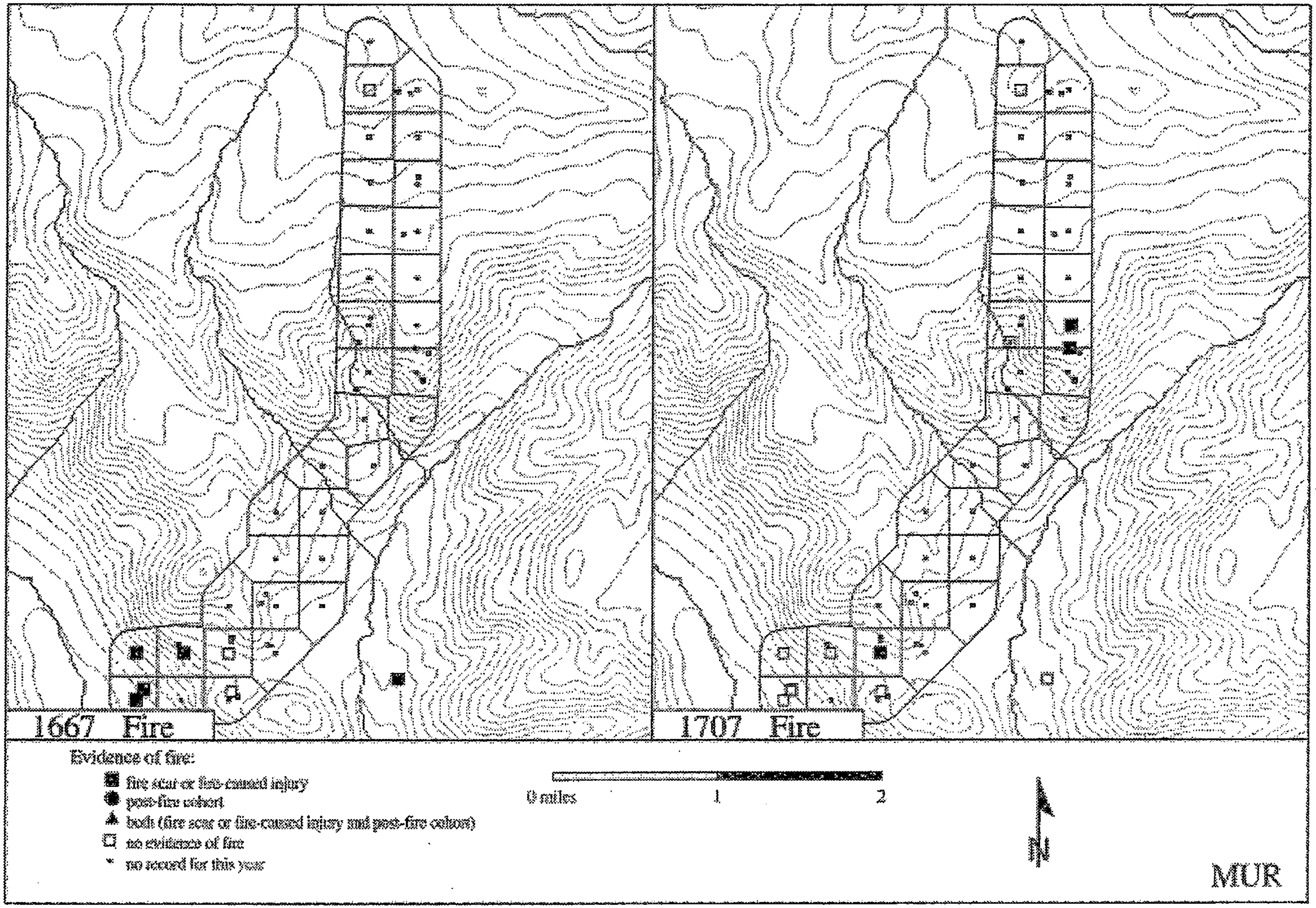


Figure 46. Number of fires within cells at MUR (1650-1900), by forest type (top panel, Table 2) and elevation (bottom panel). Number of fires includes only those fire years which were recorded on ≥2 trees at a site.

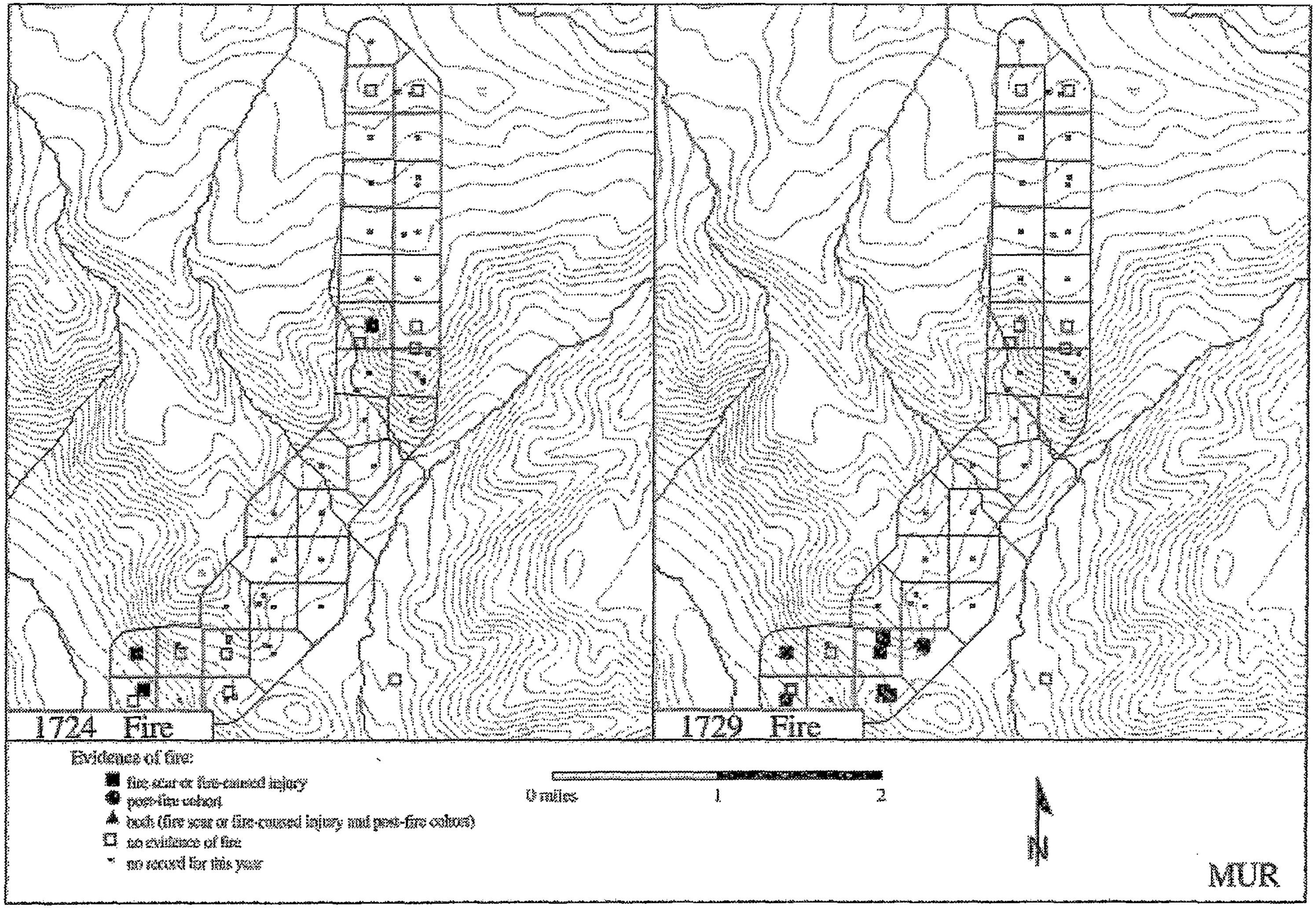
Maps of surface fires at MUR

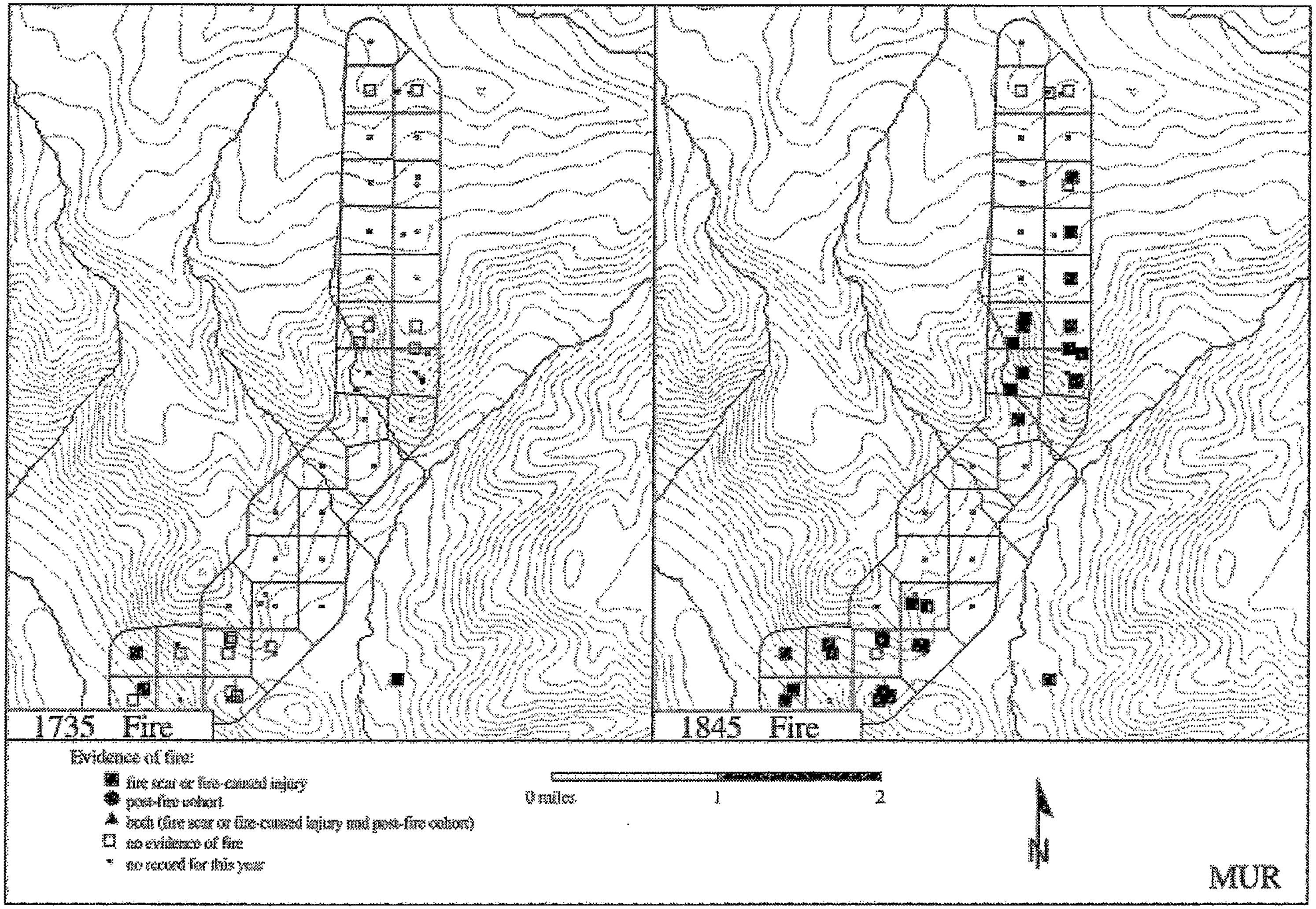
The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.

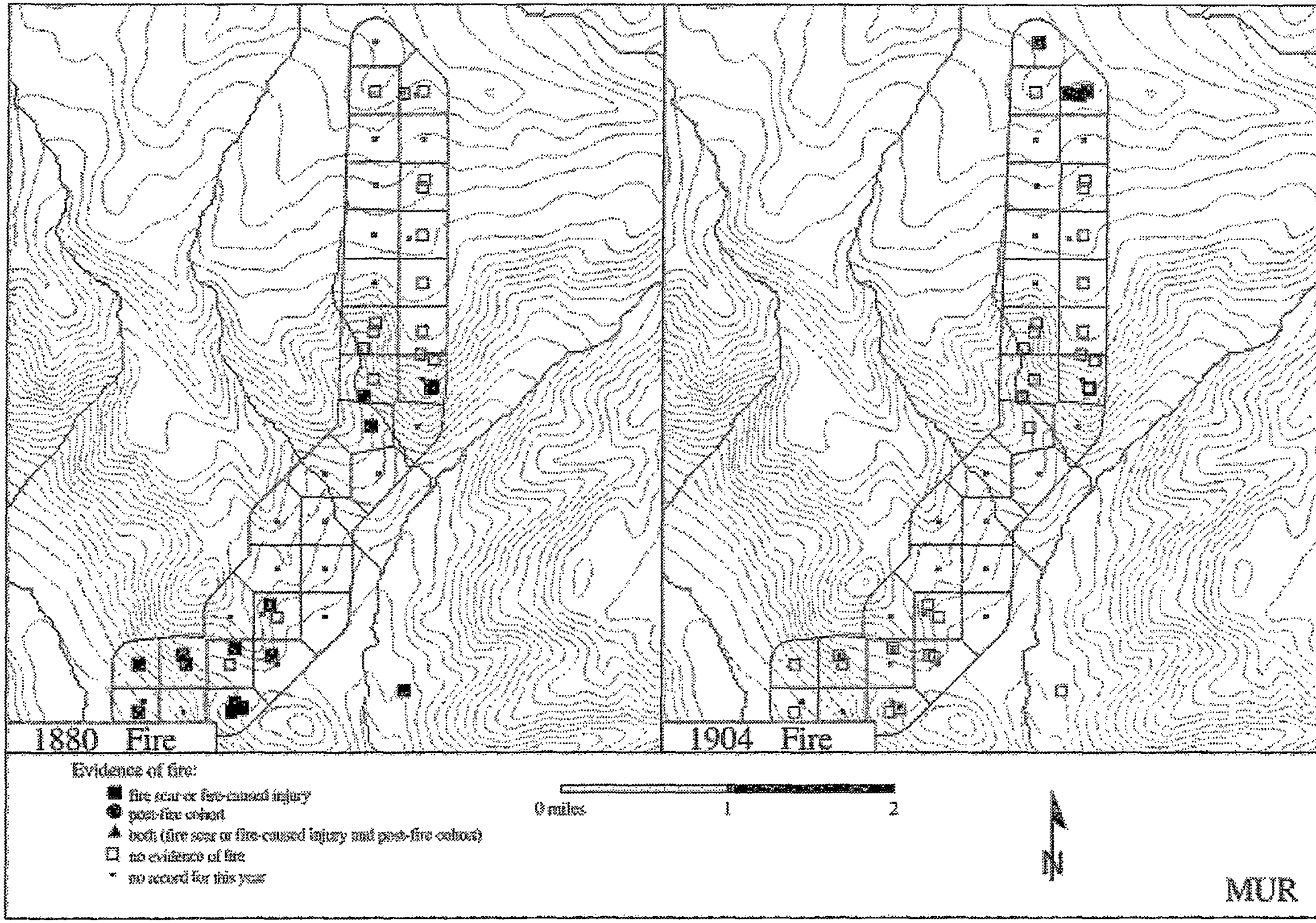

1632 Fire
1660 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
MUR



1667 Fire
1707 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
MUR


1724 Fire
1729 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
MUR


1735 Fire
1845 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
MUR


1880 Fire
1904 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
MUR

EASTERN UINTAH MOUNTAINS- ASHLEY NATIONAL FOREST (BRO)

Study Area

We sampled a grid of 30 plots over 1325 acres near Brownie Creek, on the Vernal Ranger District of the Ashley National Forest in Uintah county, Utah (Figure 47). The plots ranged in elevation from 7781 to 9671 feet, and slope from 2-72%. The plots were sampled on a range of aspects, although most plots were on south and west aspects (70%, Figure 48). The topography of the plots we sampled was generally similar to that of the sampling area at this site.

Results

Tree recruitment

Our plots included 841 total trees (80% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 749 trees and were able to crossdate most of these (730 trees, or 97% of sampled trees). The trees that occurred on our plots included a range of species (Figure 49). Trees were recruited into the sampled plots between 1400 and 1973, although most trees (80%) were recruited after 1874 (Figure 50).

Average tree density was higher at plots in 2000 than in 1860 for all 9 of the forest types that we assigned to the sampled plots at this site (shrubland, sagebrush, pinyon-juniper, ponderosa, mixed conifer, aspen-mixed conifer, aspen, lodgepole and spruce-fir, Figure 51, Table 2).

Surface fires

We removed fire-scarred sections from a total of 75 trees at BRO. We sampled more than half of these (57%) in the 19 of our 30 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were ponderosa pine (49%), Douglas-fir (23%) or lodgepole pine (17%), but we also sampled a few fire-scarred subalpine fir, Engelmann spruce and Rocky Mountain juniper. Most of the trees we sampled were logs or snags (55%), with the rest live trees. We were able to crossdate sections from all of the sampled trees at this site. These trees yielded 114 fire scars, and 29 eroded fire scars or abrupt changes in ring width (1371 to 2004; Figure 52). We were able to assign an intra-ring position to 83% of the fire scars. Most of the scars from the analysis period (1650-1900) were created by fires burning late in the cambial growing season or when the cambium was dormant (94% of assigned scars, Figure 53).

The number of surface fires during the analysis period (1650-1900) did not vary much with elevation and forest type at BRO (Figure 54).

Figures and tables for BRO

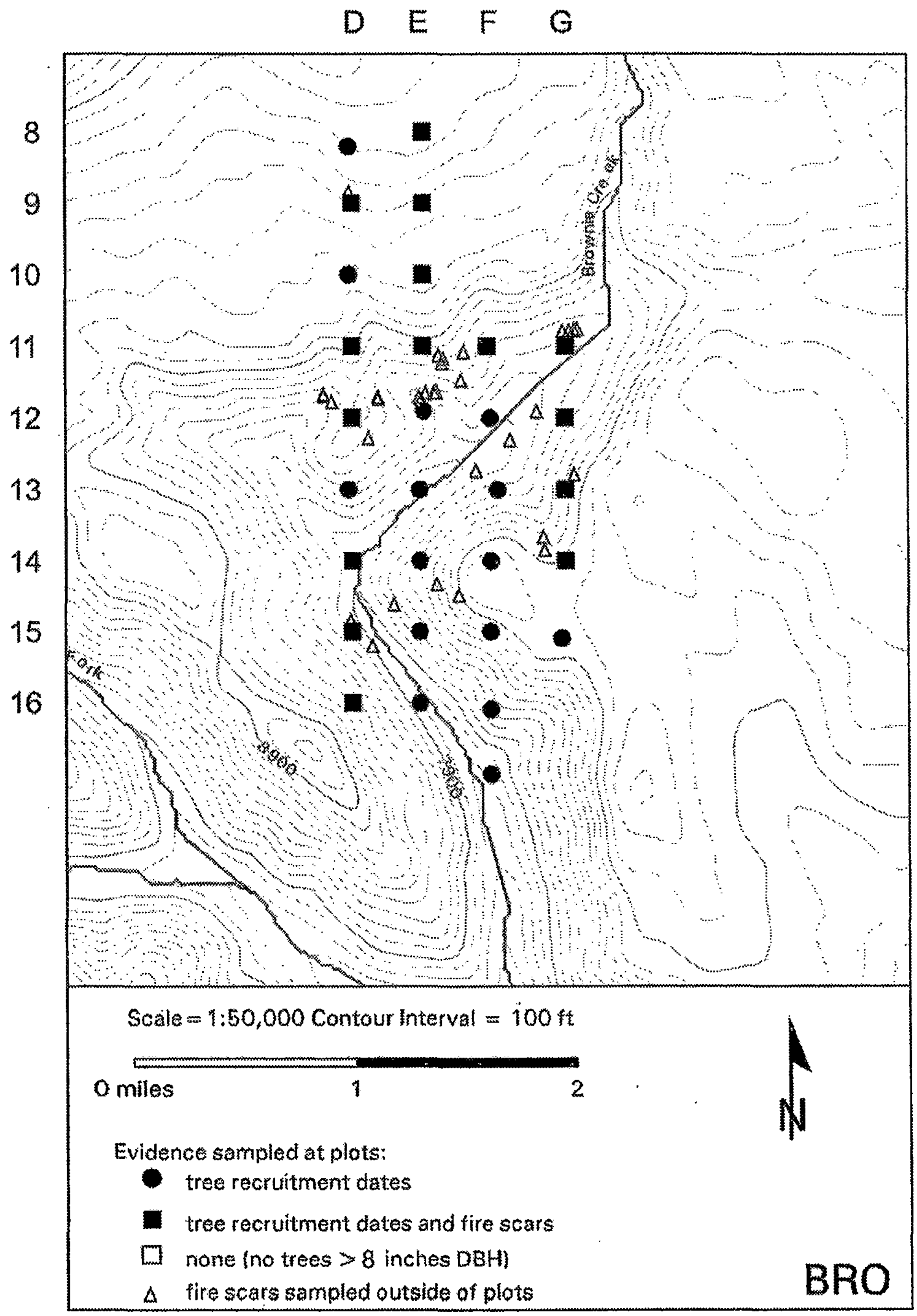


Figure 47. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the northwestern most plot is 8D, the next plot to the east is 8E, etc. Most of the fire-scarred trees (57% of 75 dated trees) were sampled within plots and so are not mapped individually.

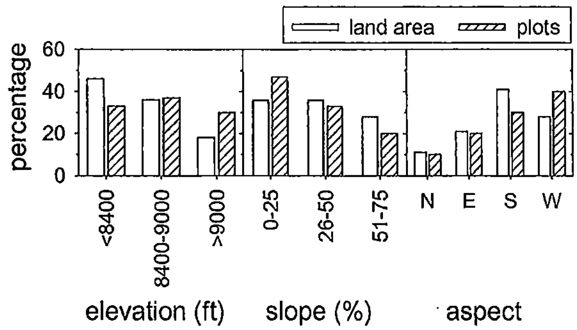


Figure 48. Distribution of topography for sampled plots and for land area at BRO. Aspect classes are 90° wide, beginning with 46° for east (E). Land area was derived from a digital elevation model.

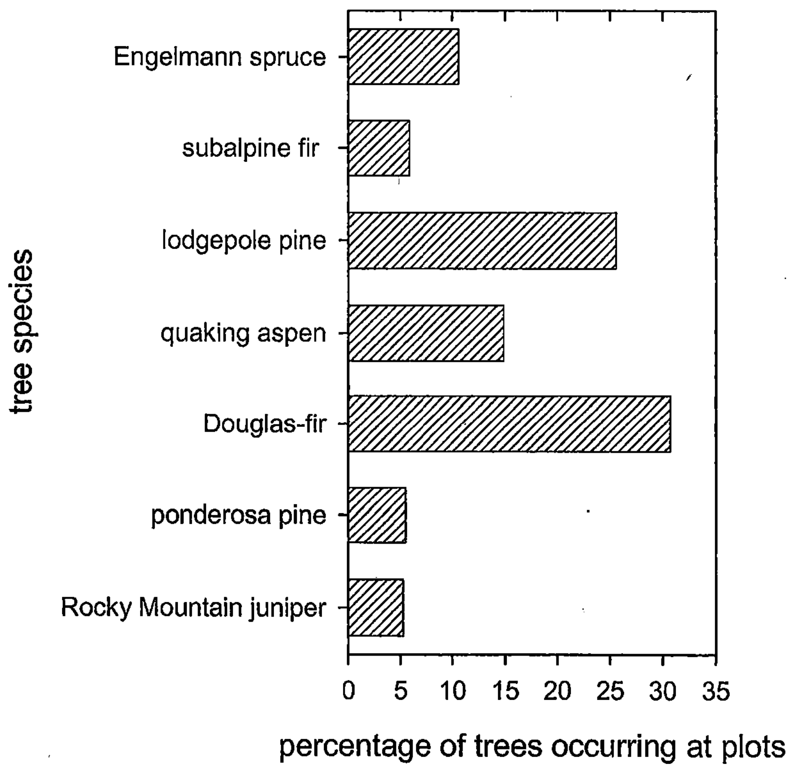


Figure 49. Species distribution of all trees that occurred in plots at BRO. In addition, 15 limber pine trees occurred in our plots but are not shown.

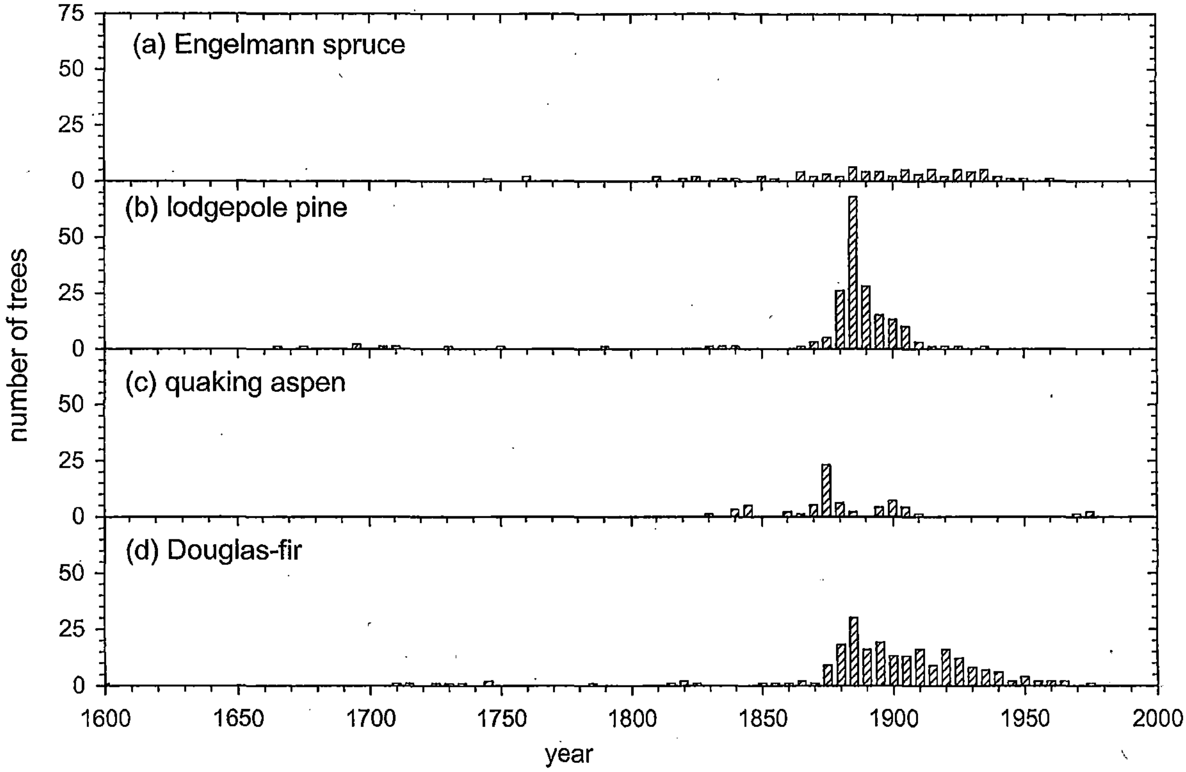


Figure 50. Distribution of tree-recruitment dates by species at BRO, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

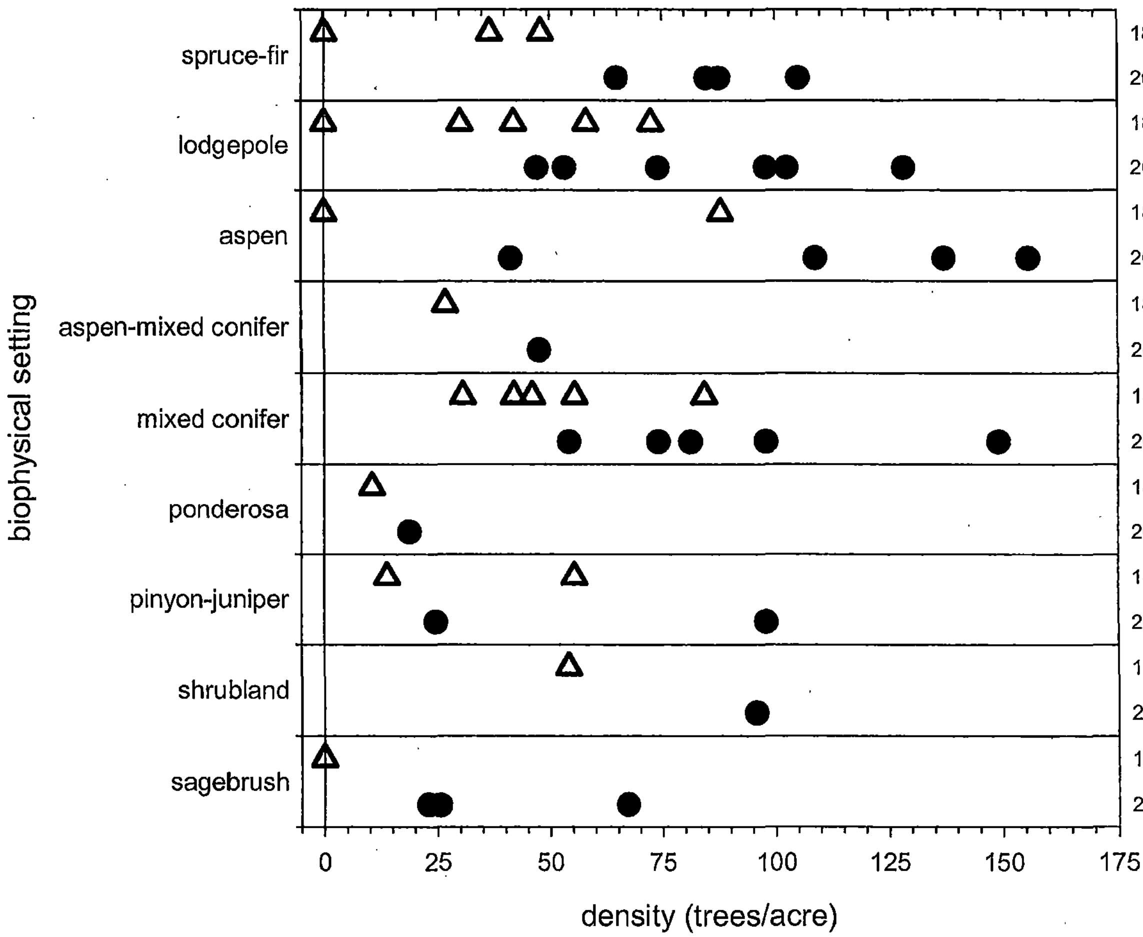


Figure 51. Density of live trees >8 inches DBH at each plot at BRO, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

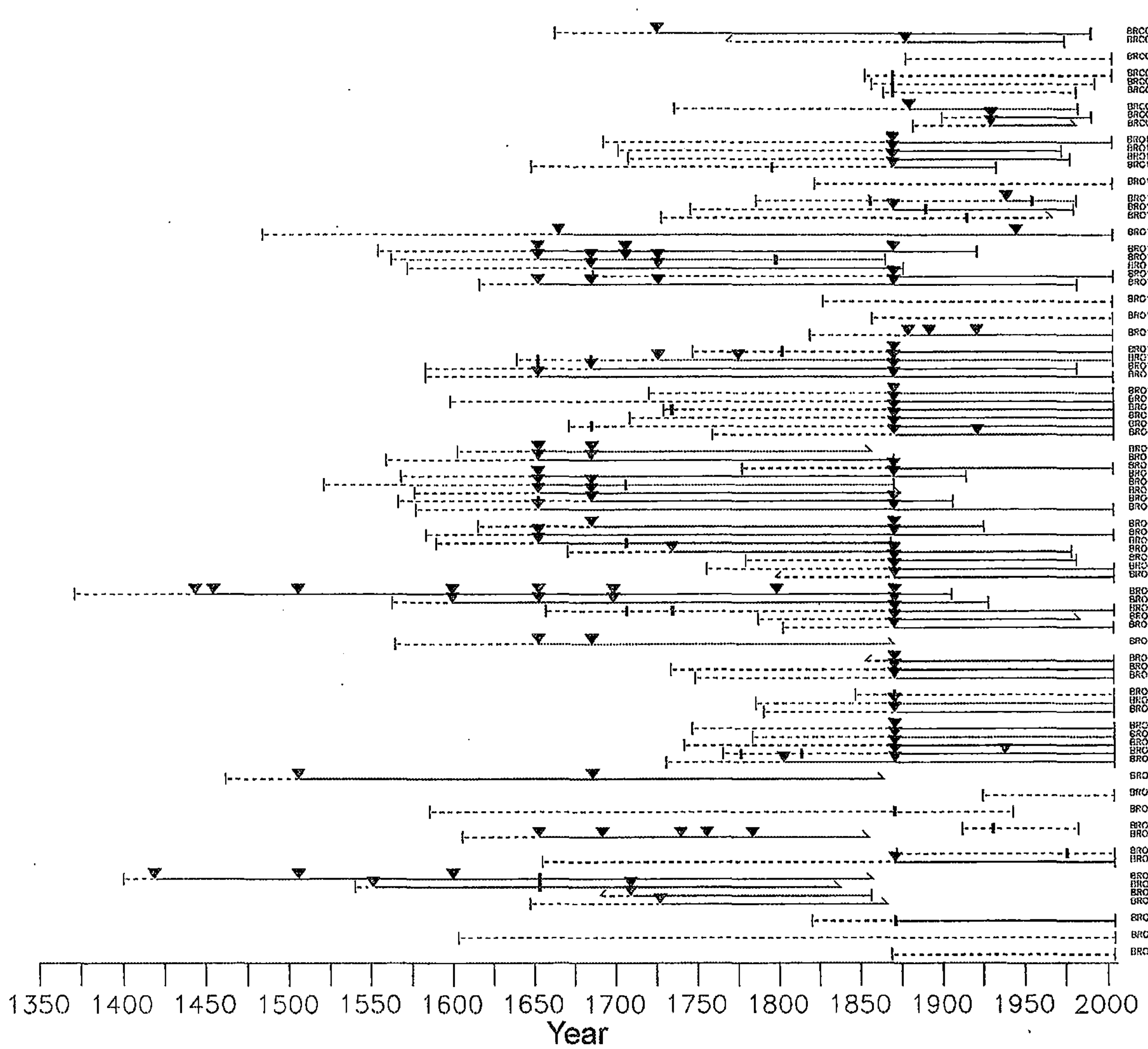


Figure 52. Fire chronologies at BRO, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

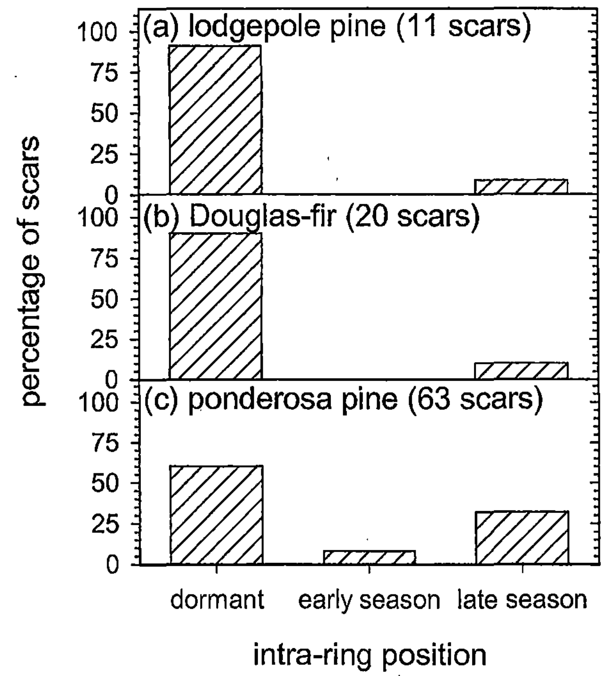


Figure 53. Intra-ring position of fire scars at BRO (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only species that comprised >10% of trees are plotted. We also dated scars from some subalpine fir, Engelmann spruce and Rocky Mountain juniper, but these species yielded too few scars with an intra-ring position to plot here.

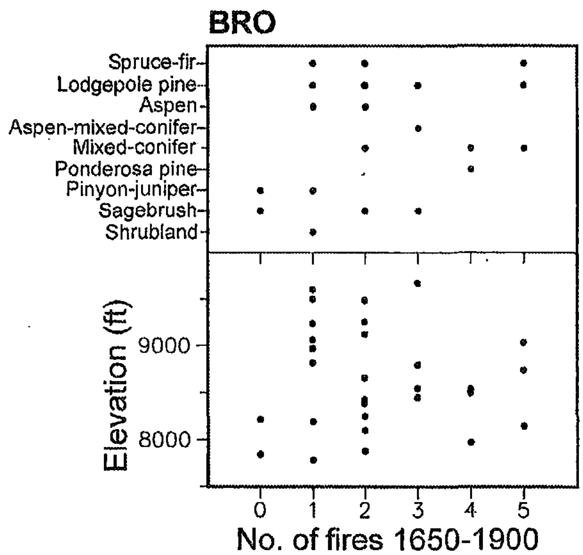
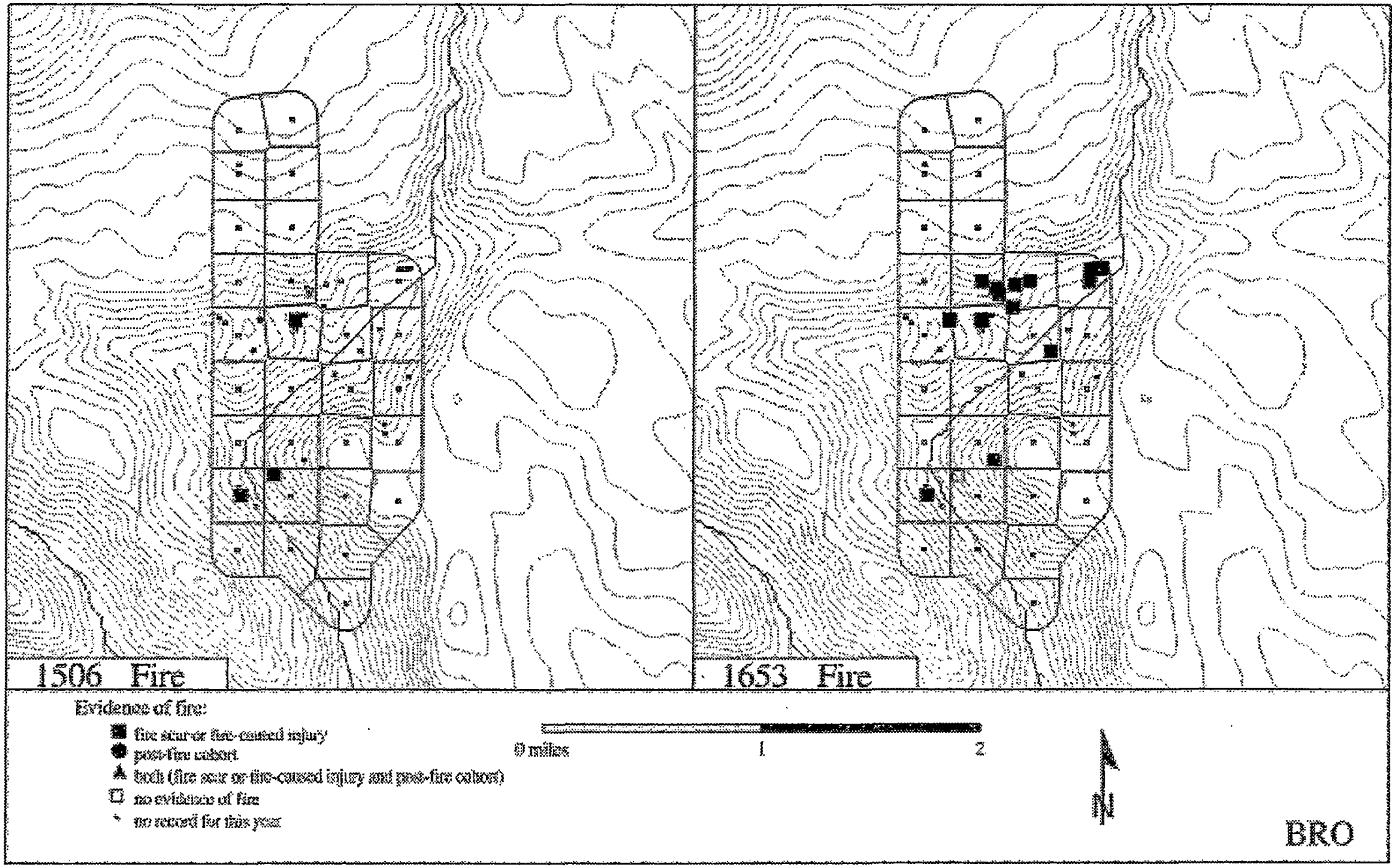
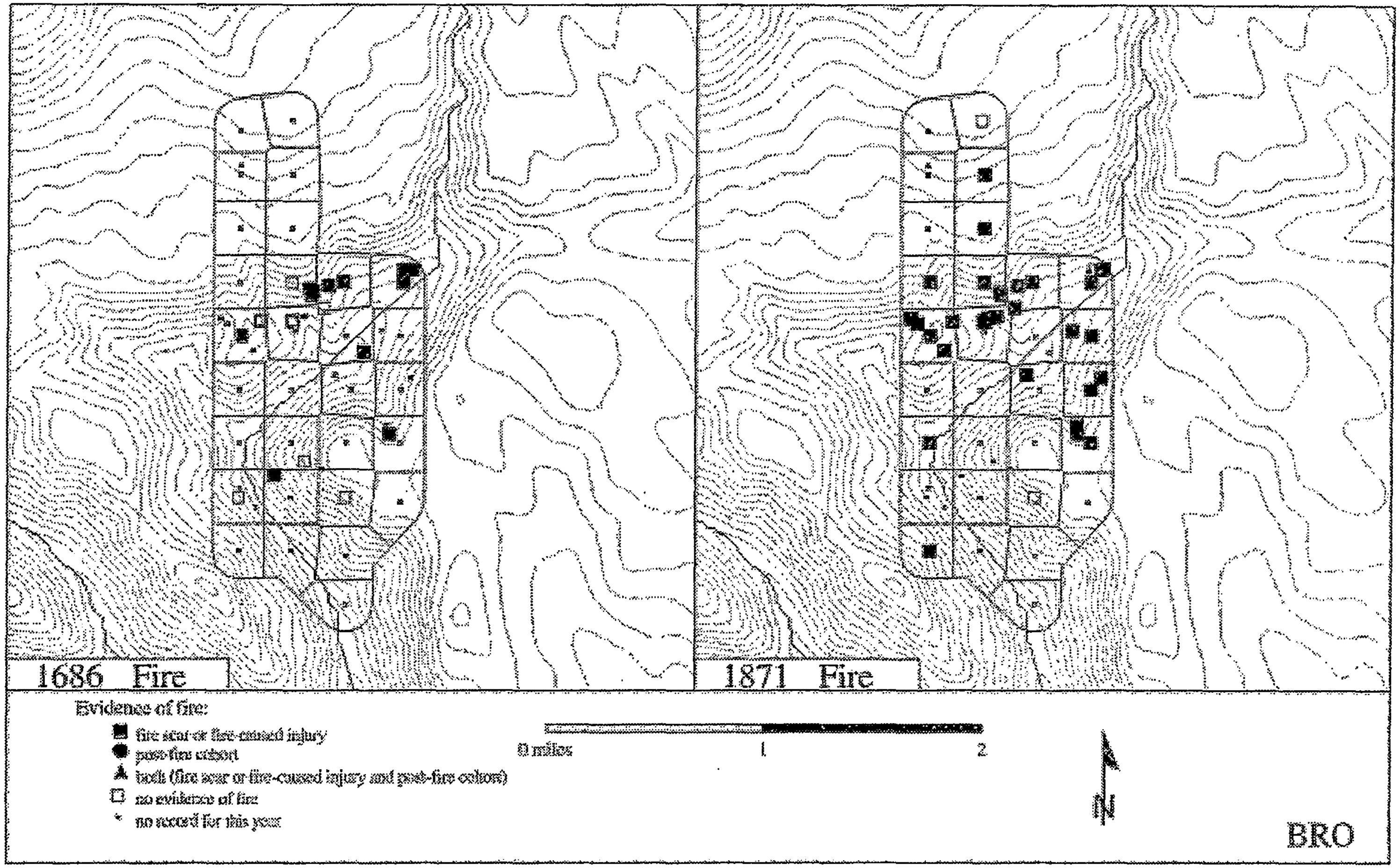


Figure 54. Number of fires within cells at BRO (1650-1900), by forest type (top panel, Table 2) and elevation (bottom panel). Number of fires includes only those fire years which were recorded on ≥2 trees at a site.

Maps of surface fires at BRO

The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.


1506 Fire
1653 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BRO


1686 Fire
1871 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BRO

WASATCH PLATEAU - MANTI-LA SAL NATIONAL FOREST (EPH)

Study Area

We sampled a grid of 30 plots over 1414 acres in Ephraim Canyon, on the Sanpete Ranger District of the Manti-La Sal National Forest in Sanpete county, Utah (Figure 55). The plots ranged in elevation from 7604 to 9470 feet, and in slope from 3 to 63%. The plots were sampled on a range of aspects, although most plots were on north or west aspects (80%, Figure 56). The topography of the plots we sampled was generally similar to that of the sampling area at this site.

Results

Tree recruitment

Our plots included 856 total trees (85% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 756 trees and were able to crossdate most of these (725 trees, or 96% of sampled trees). The trees that occurred on our plots included a range of species (Figure 57). Trees were recruited into the sampled plots between 1593 and 1983, although most trees (80%) were recruited after 1866 (Figure 58).

Average tree density was higher at plots in 2000 than in 1860 for all 5 of the forest types that we assigned to the sampled plots at this site (oak, mixed conifer, aspen-mixed conifer, aspen and spruce-fir, Figure 59, Table 2).

Surface fires

We removed fire-scarred sections from a total of 38 trees at EPH. We sampled fewer than half of these (39%) in the 5 of our 30 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were white fir (39%), Douglas-fir (26%) or limber pine (21%), but we also sampled a few fire-scarred Engelmann spruce, subalpine fir and aspen. Some of the trees we sampled were logs, snags or stumps (39%), with the rest live trees. We were unable to crossdate sections from some of the sampled trees (18%). Those that we did crossdate yielded 48 fire scars, and 17 eroded fire scars or abrupt changes in ring width (1552 to 2004; Figure 60). We were able to assign an intra-ring position to 77% of the fire scars. Most of the scars from the analysis period (1650-1900) were created by fires burning when the cambium was dormant (86% of assigned scars, Figure 61). There were not enough fire scars during the analysis period for us to determine the number of fires.

Figures and tables for EPH

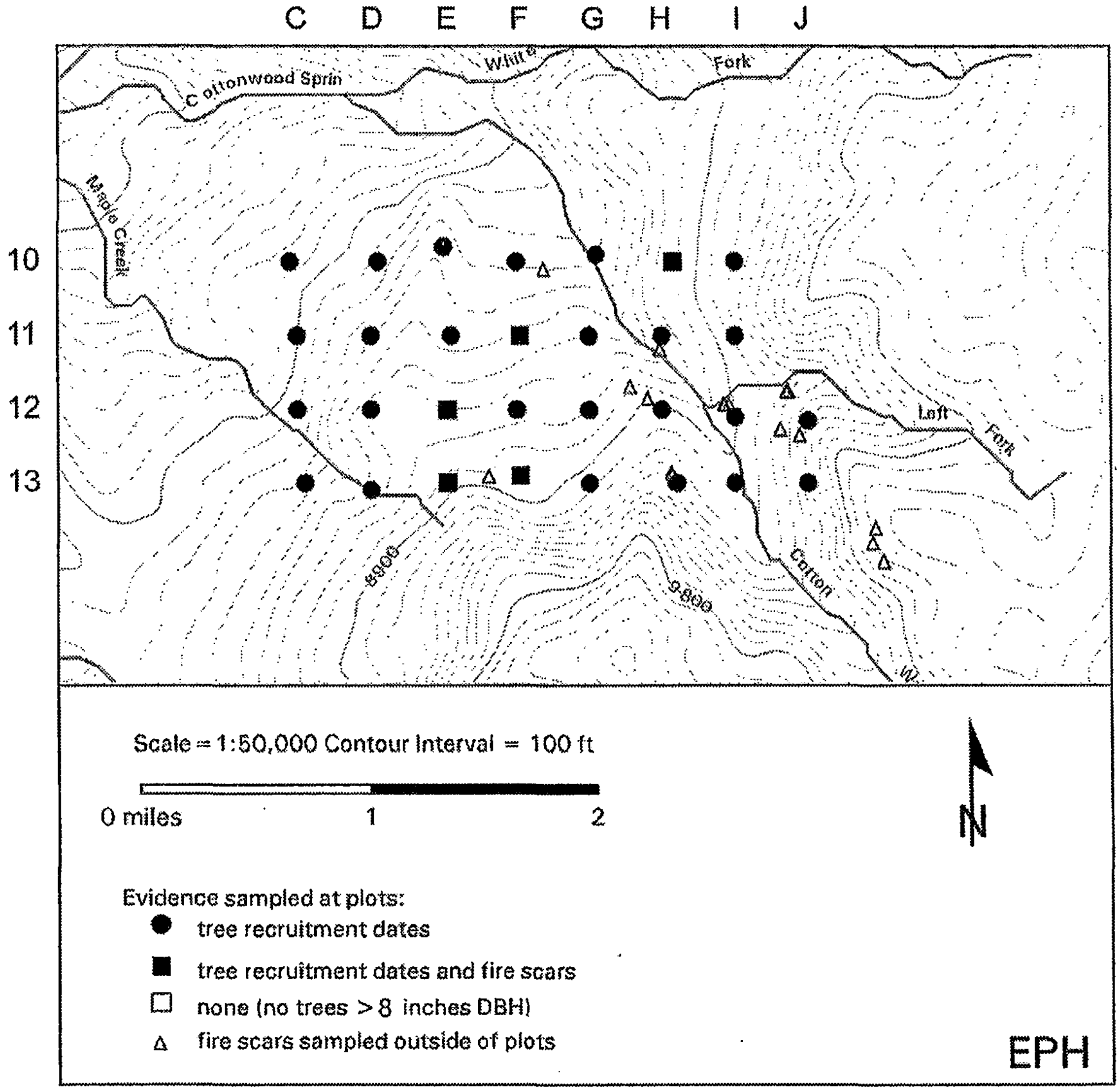


Figure 55. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the northwestern most plot is 10C, the next plot to the east is 10D, etc. Some of the fire-scarred trees (39% of 31 dated trees) were sampled within plots and so are not mapped individually.

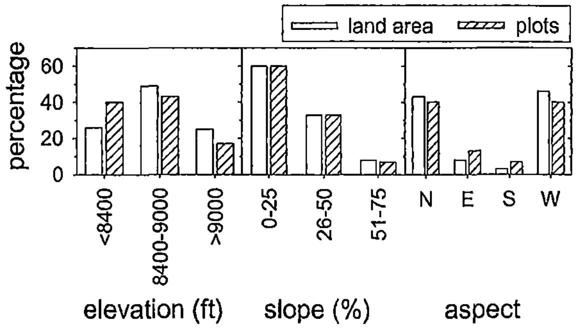


Figure 56. Distribution of topography for sampled plots and for land area at EPH. Aspect classes are 90° wide, beginning with 46° for east (E). Land area was derived from a digital elevation model.

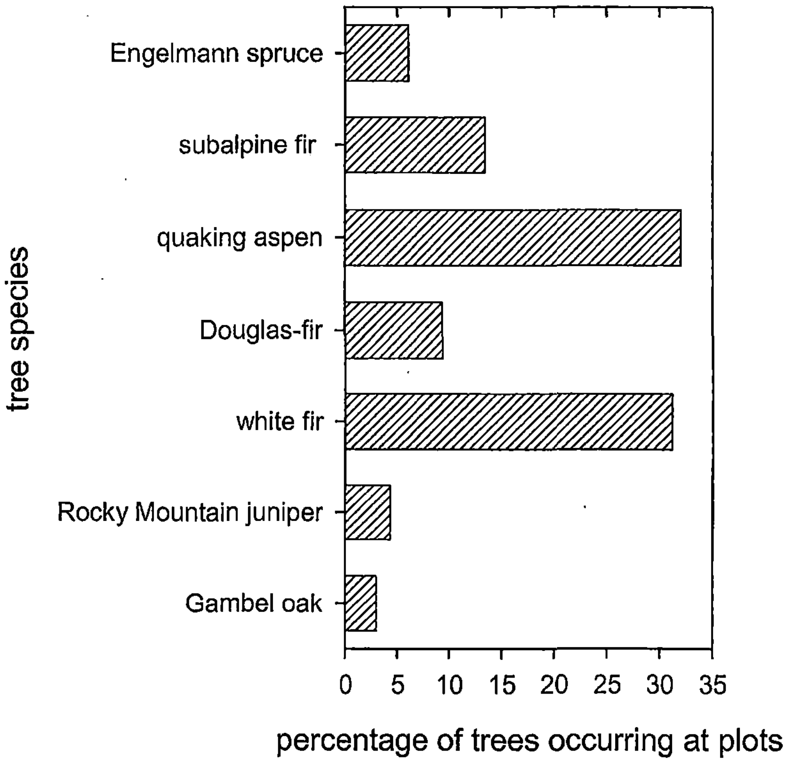


Figure 57. Species distribution of all trees that occurred in plots at EPH. In addition, 5 limber and 1 ponderosa pine trees occurred in our plots but are not shown.

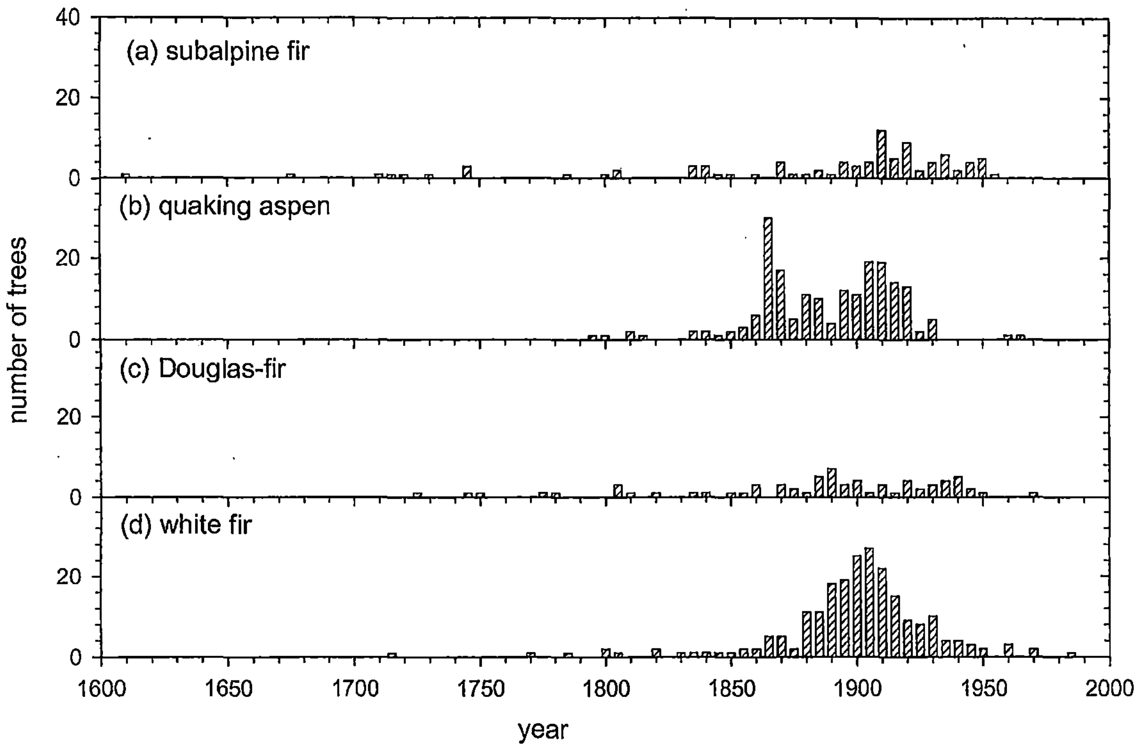


Figure 58. Distribution of tree-recruitment dates by species at EPH, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

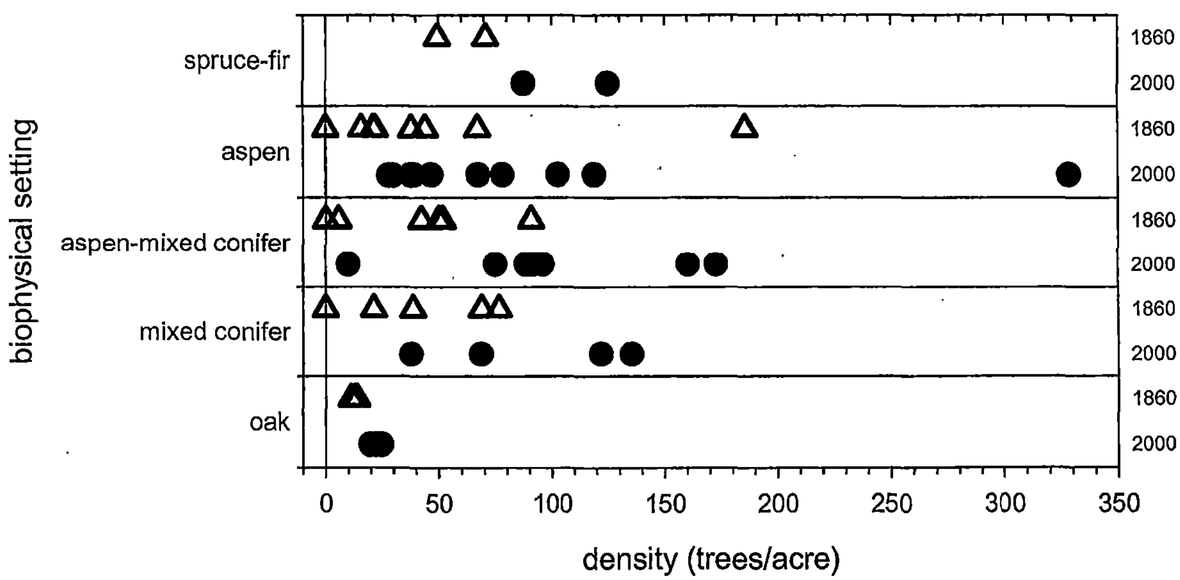


Figure 59. Density of live trees >8 inches DBH at each plot at EPH, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

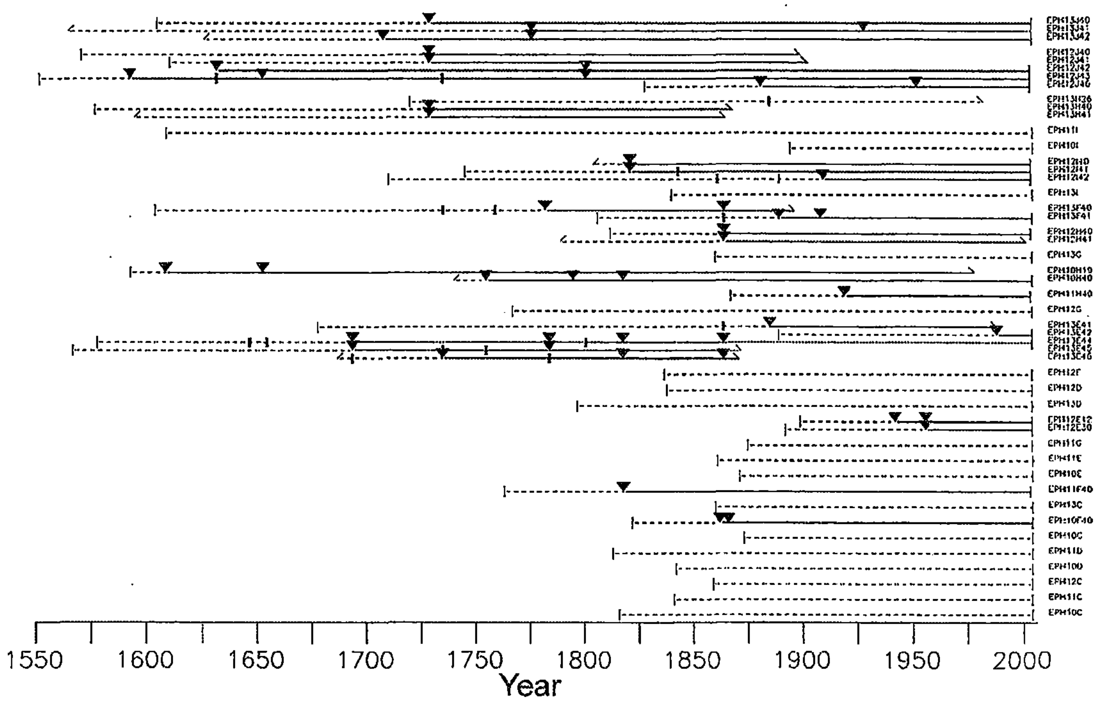


Figure 60. Fire chronologies at EPH, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

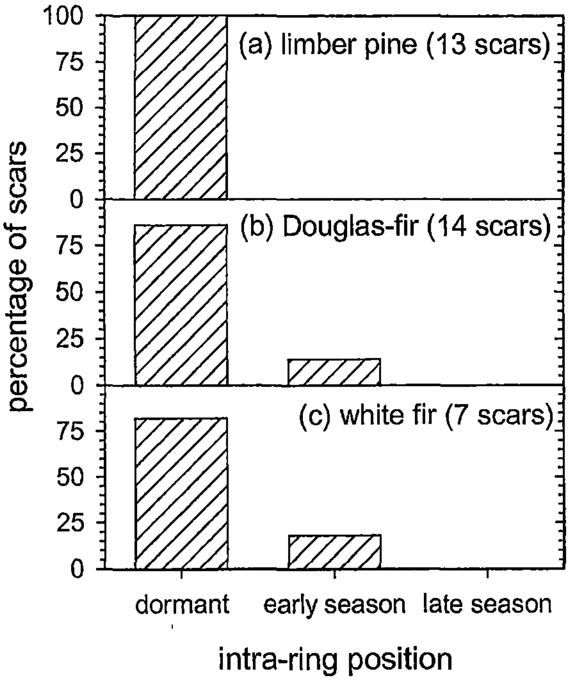
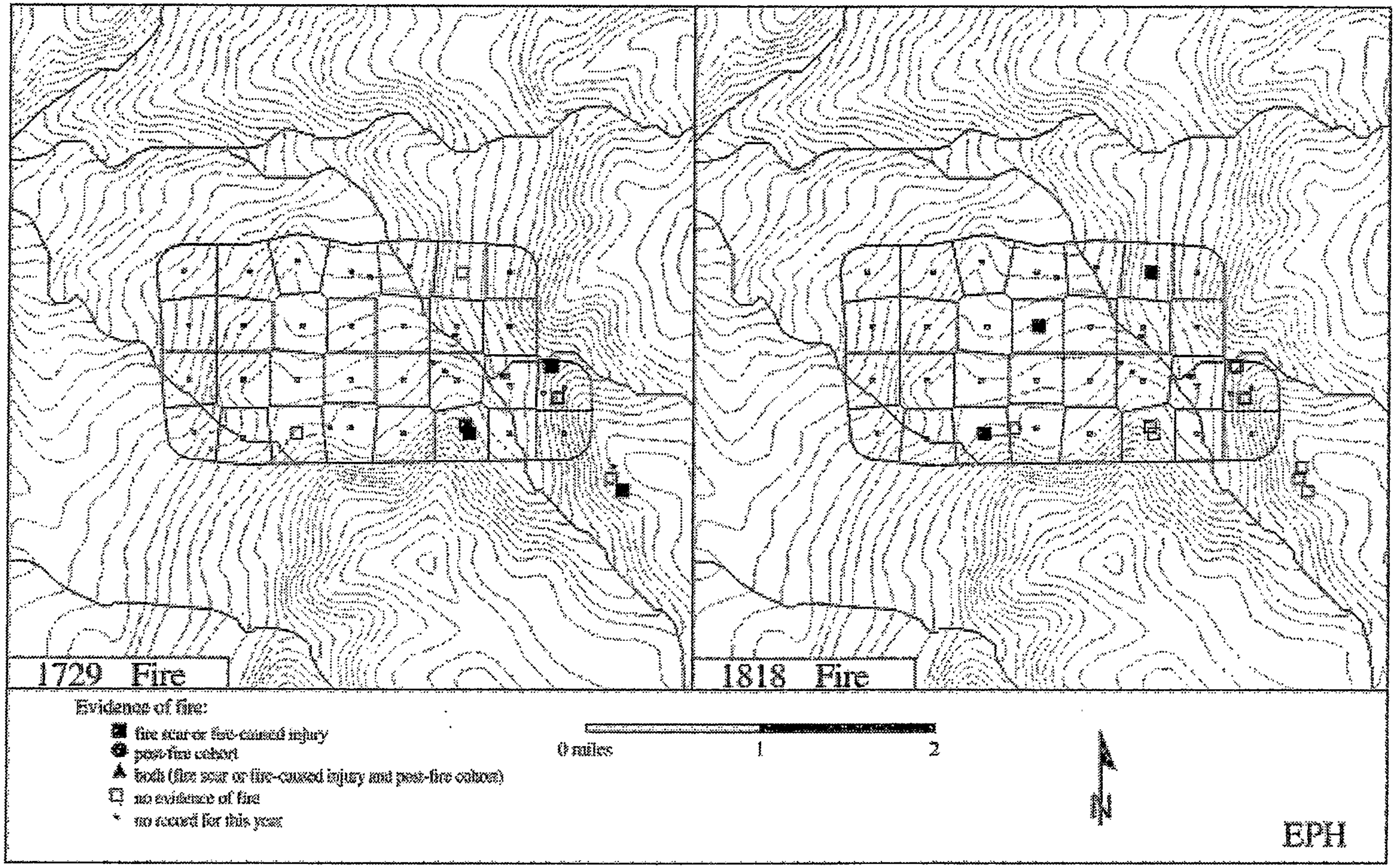
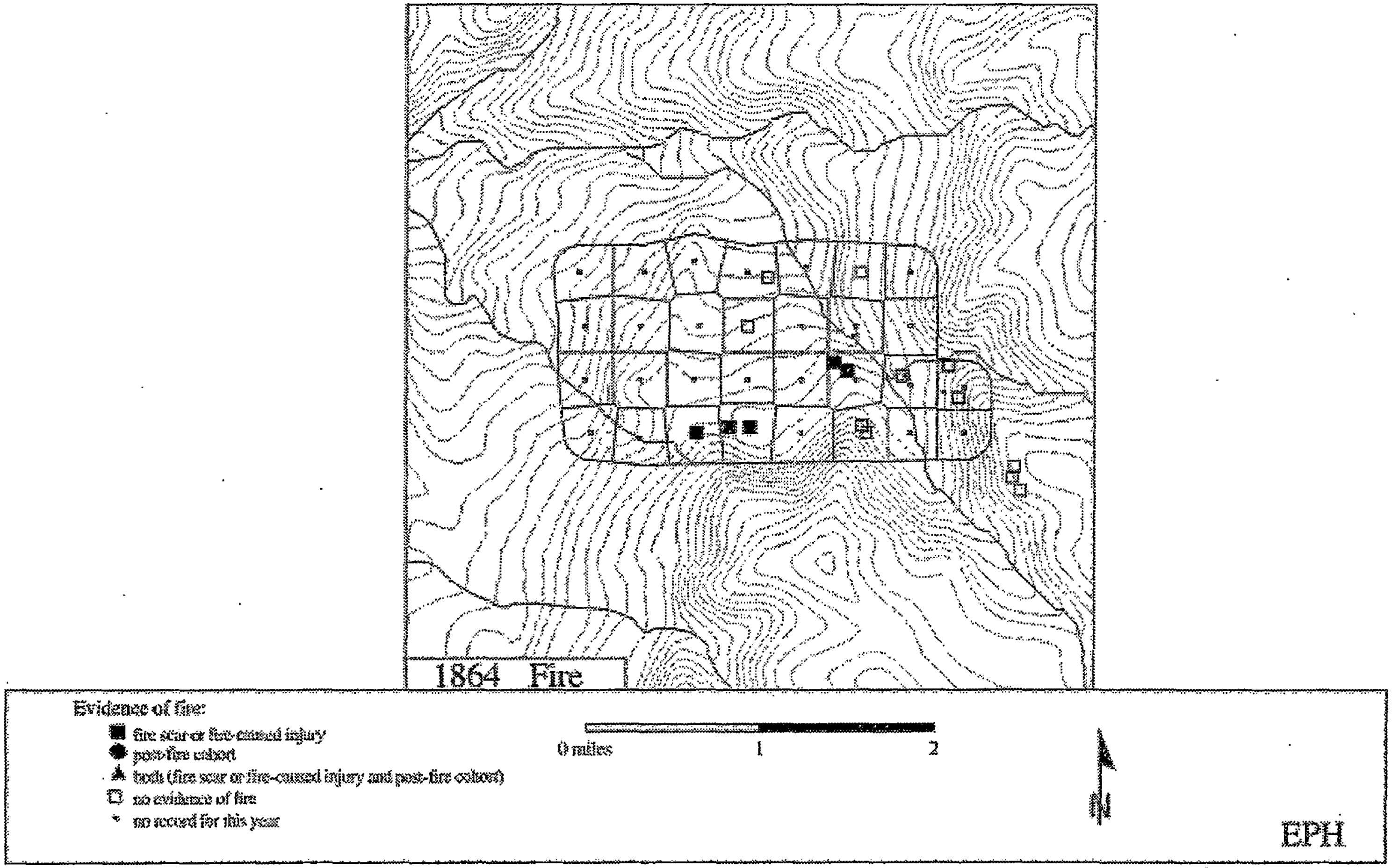


Figure 61. Intra-ring position of fire scars at EPH (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only species that comprised >10% of trees are plotted. We also dated scars from some subalpine fir, Engelmann spruce and quaking aspen, but these species yielded too few scars with an intra-ring position to plot here.

Maps of surface fires at EPH

The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.


1729 Fire
1818 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
EPH


1864 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
EPH

ABAJO MOUNTAINS - MANTI-LA SAL NATIONAL FOREST (ABM)

Study Area

We sampled a grid of 28 plots over 1572 acres near North Canyon Creek on the east side of the Abajo Mountains. This site is on the Monticello Ranger District of the Manti-La Sal National Forest in San Juan county, Utah (Figure 62). The plots ranged in elevation from 8389 to 10600 ft, in slope from 1-69%, and the plots were sampled on a range of aspects, although most plots were on north or east aspects (77%, Figure 63). The topography of the plots we sampled was generally similar to that of the sampling area at this site, except that we over sampled plots at low elevations (<9000 ft) and under sampled plots at mid elevations (9000-10000 ft).

Results

Tree recruitment

Our plots included 754 total trees (77% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 739trees and were able to crossdate most of these (711 trees, or 96% of sampled trees). The trees that occurred on our plots included a range of species (Figure 64). Trees were recruited into the sampled plots between 1326 and 1973, although most trees (80%) were recruited after 1794 (Figure 65).

Average tree density was higher at plots in 2000 than in 1860 for all 6 of the forest types that we assigned to the sampled plots at this site (oak, ponderosa, mixed conifer, aspen-mixed conifer, aspen and spruce-fir, Figure 66, Table 2).

Surface fires

We removed fire-scarred sections from a total of 81 trees at ABM. We sampled more than half of these (63%) in the 16 of our 28 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were ponderosa pine (89%), but we also sampled a few fire-scarred Engelmann spruce, Douglas-fir, Gambel oak (*Quercus gambelii* Nutt.), white fir and subalpine fir. Most of the trees we sampled were logs, snags or stumps (68%), with the rest live trees. We were unable to crossdate sections from some of the sampled trees (10%). Those that we did crossdate yielded 196 fire scars, and 13 eroded fire scars or abrupt changes in ring width (1120 to 2003; Figure 67). We were able to assign an intra-ring position to 62% of the fire scars. About half of the scars from the analysis period (1650-1900) were created by fires burning when the cambium was dormant (49% of assigned scars, Figure 68).

The number of surface fires during the analysis period (1650-1900) varied with elevation and forest type at ABM (Figure 69), with fires most frequent at low elevation, and in the ponderosa forest type. Surface fires ceased in the late 1800s at this site (Figure 67).

Figures and tables for ABM

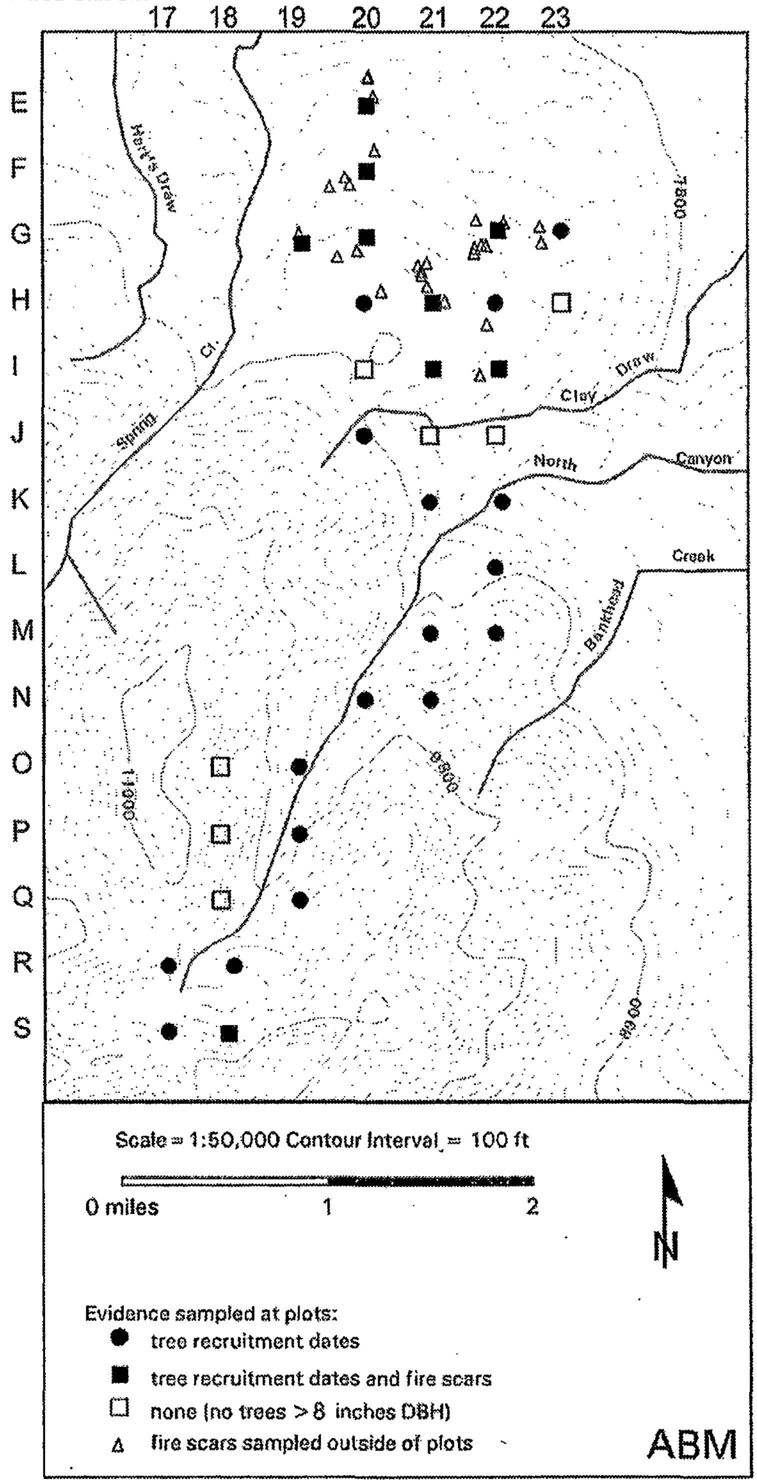


Figure 62. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the northwestern most plot is 17E, the next plot to the east is 18E, etc., but note that the order of the column and row identifiers at this site differs from that at most other sites. Most of the fire-scarred trees (63% of 73 dated trees) were sampled within plots and so are not mapped individually.

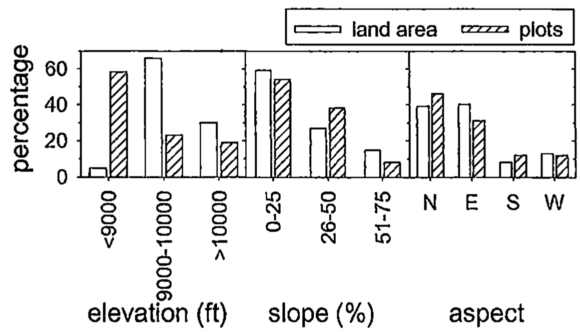


Figure 63. Distribution of topography for sampled plots and for land area at ABM. Aspect classes are 90° wide, beginning with 46° for east (E). Land area was derived from a digital elevation model.

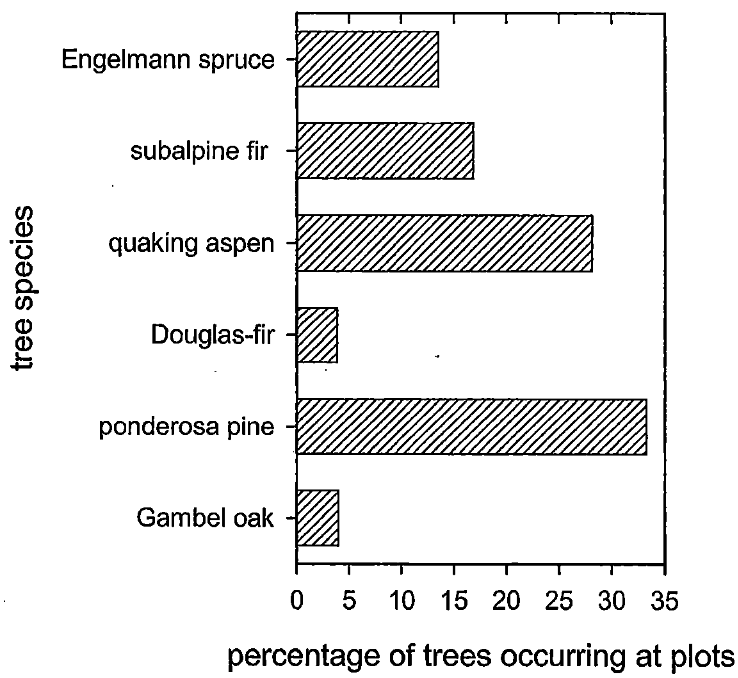


Figure 64. Species distribution of all trees that occurred in plots at ABM. In addition, 3 white fir and 2 two-needle pinyon occurred in our plots but are not shown.

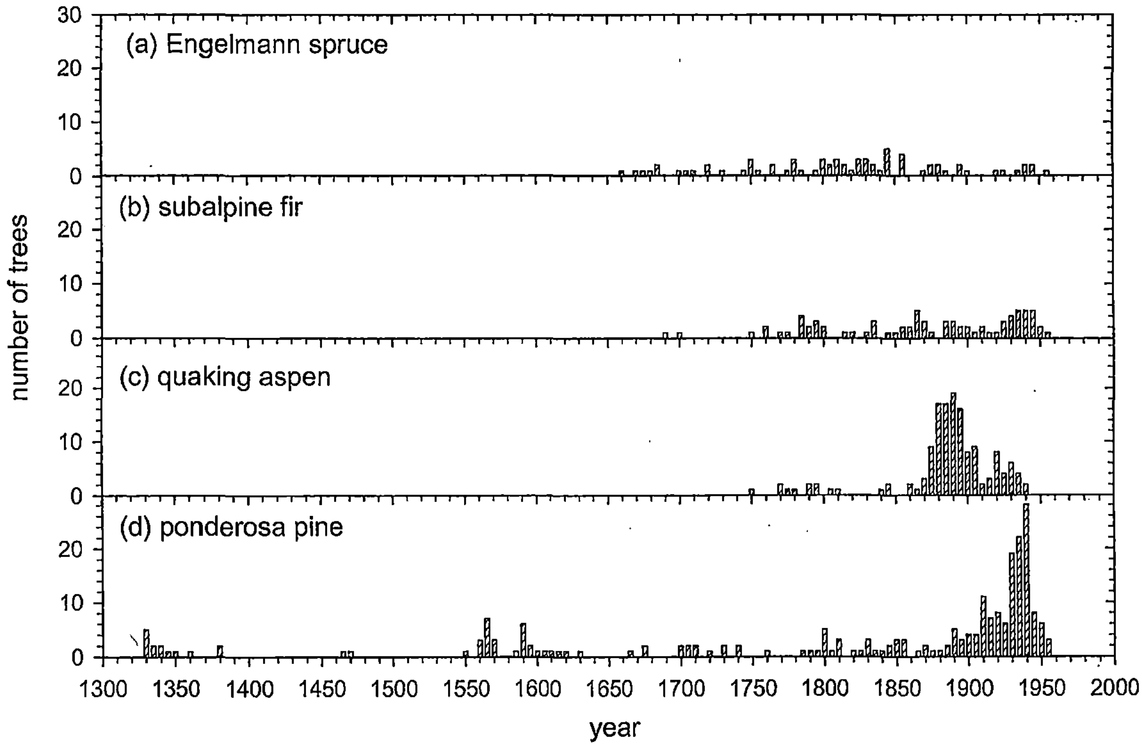


Figure 65. Distribution of tree-recruitment dates by species at ABM, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

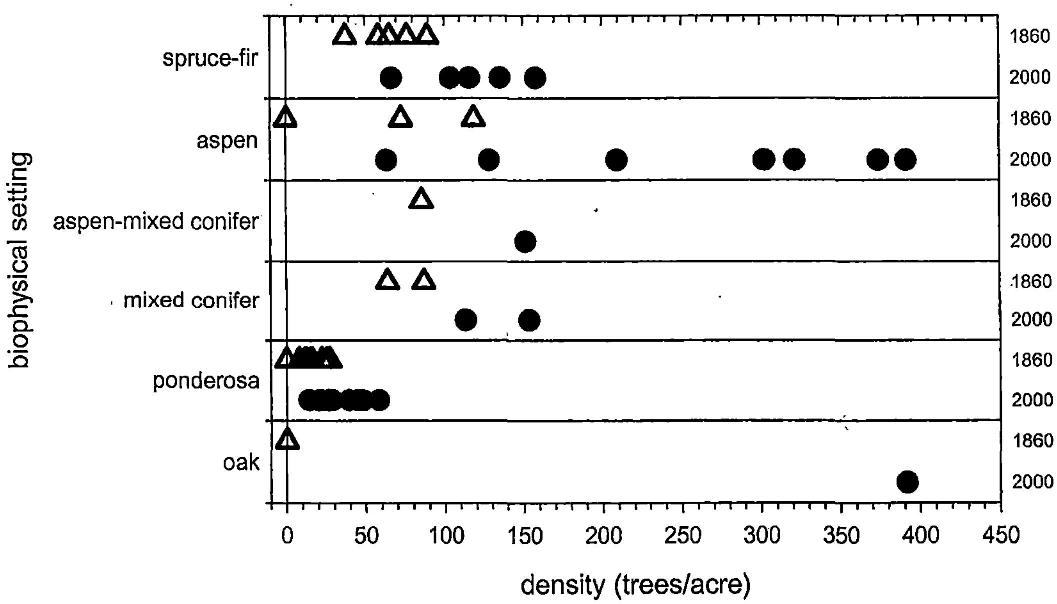


Figure 66. Density of live trees >8 inches DBH at each plot at ABM, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

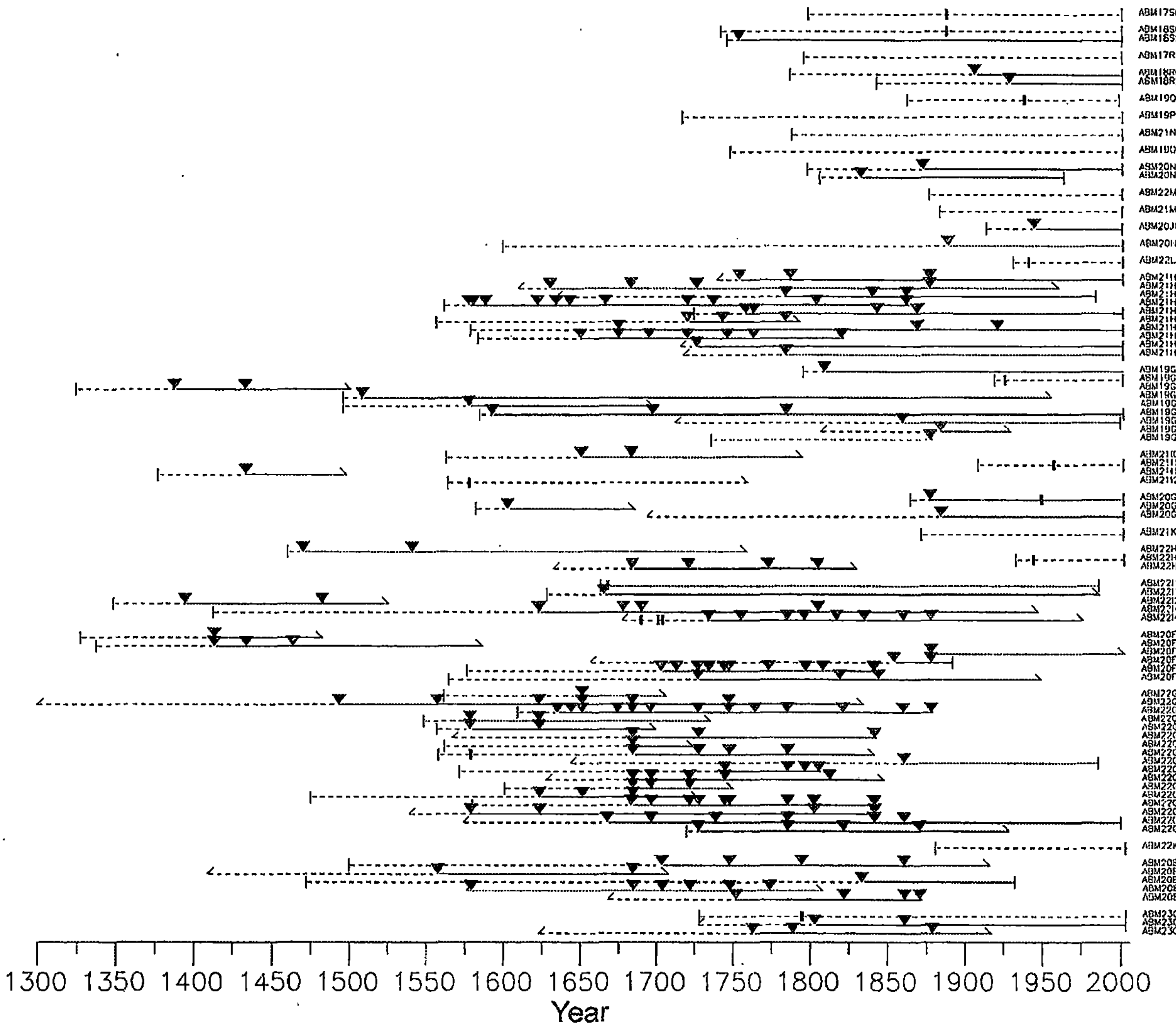


Figure 67. Fire chronologies at ABM, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

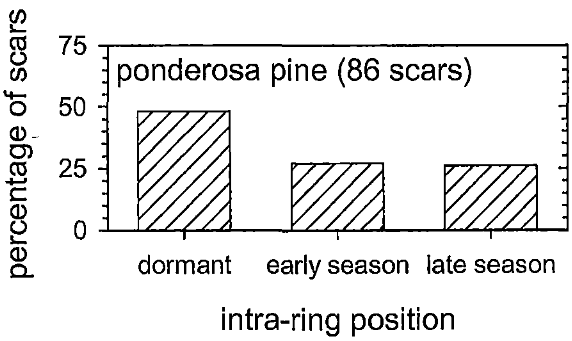


Figure 68. Intra-ring position of fire scars at ABM (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only species that comprised >10% of trees are plotted. We also dated scars from some Douglas-fir, white fir, subalpine fir, Gambel oak and Engelmann spruce, but these species yielded too few scars with an intra-ring position to plot here.

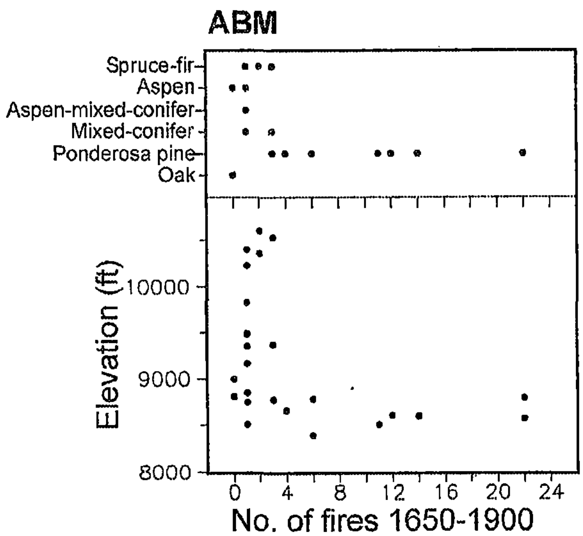
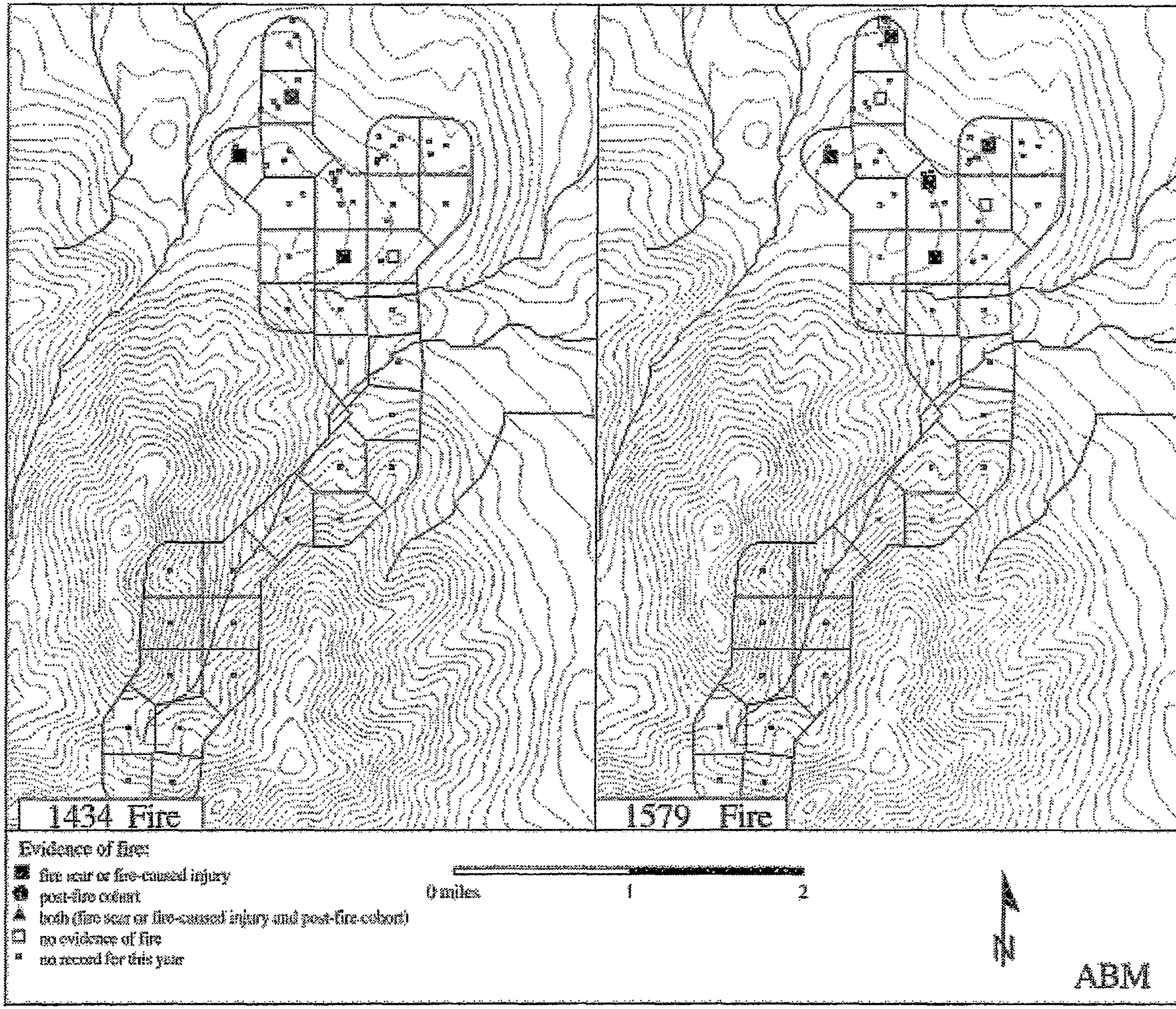
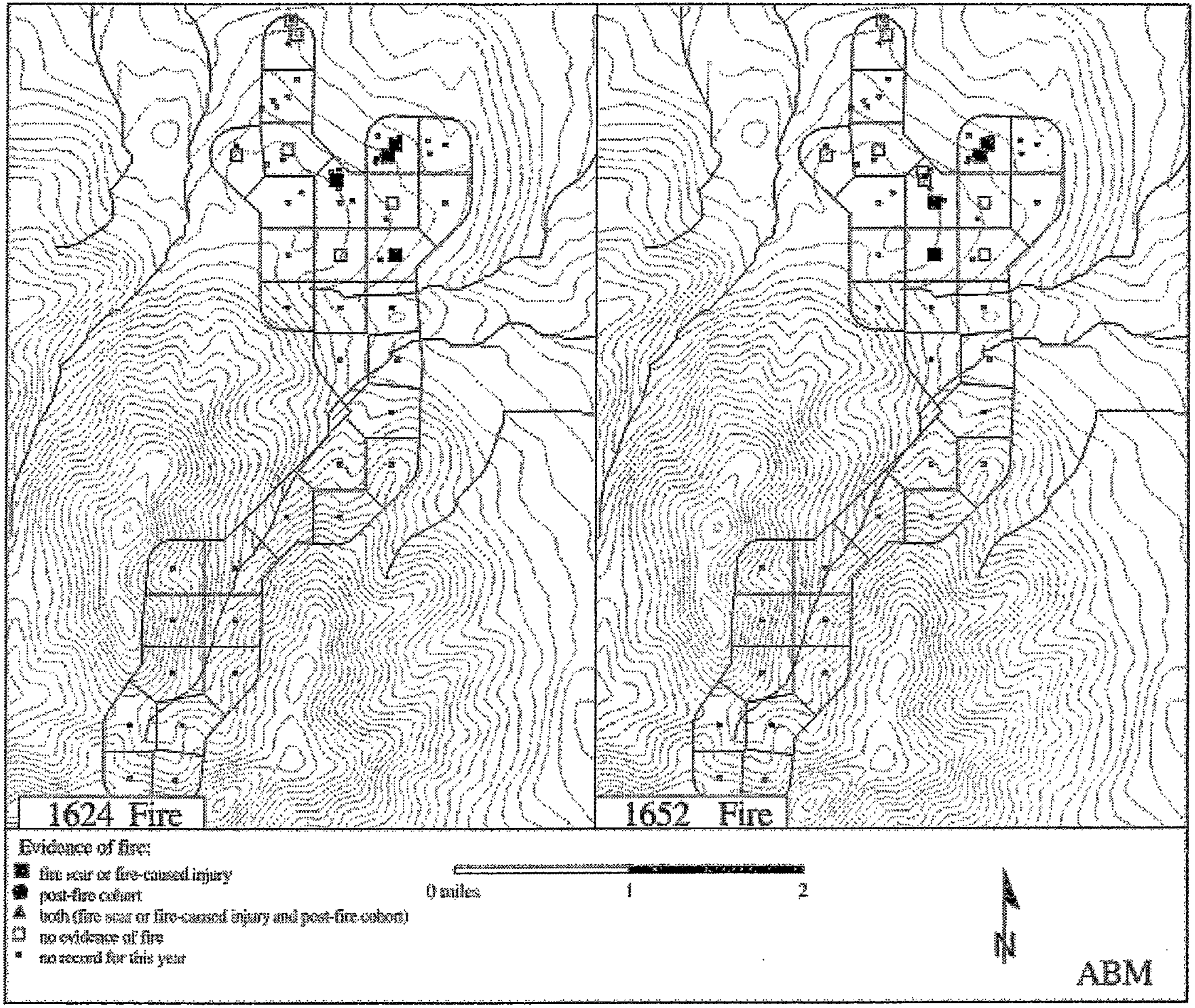


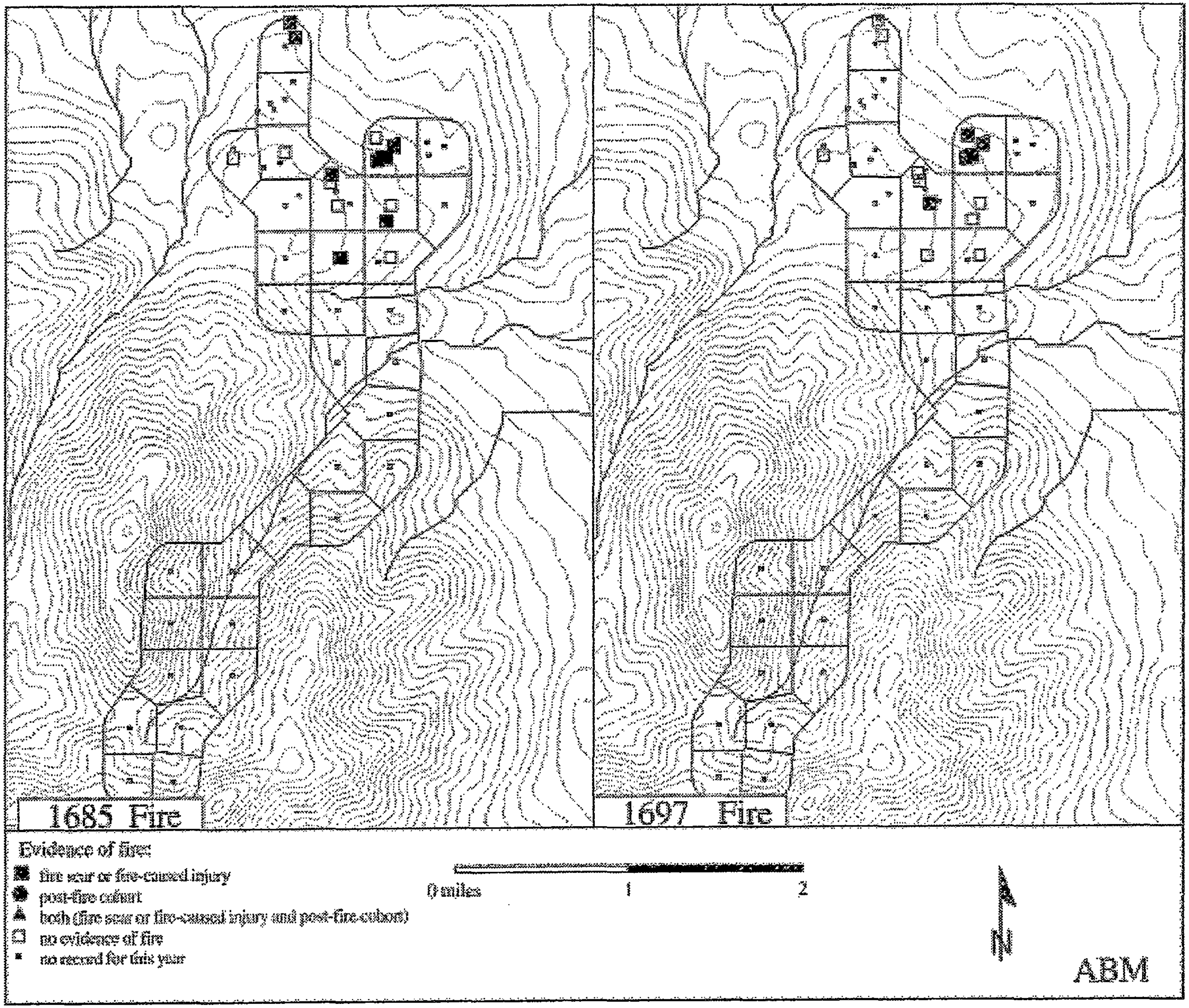
Figure 69. Number of fires within cells at ABM (1650-1900), by forest type (top panel, Table 2) and elevation (bottom panel). Number of fires includes only those fire years which were recorded on ≥2 trees at a site.

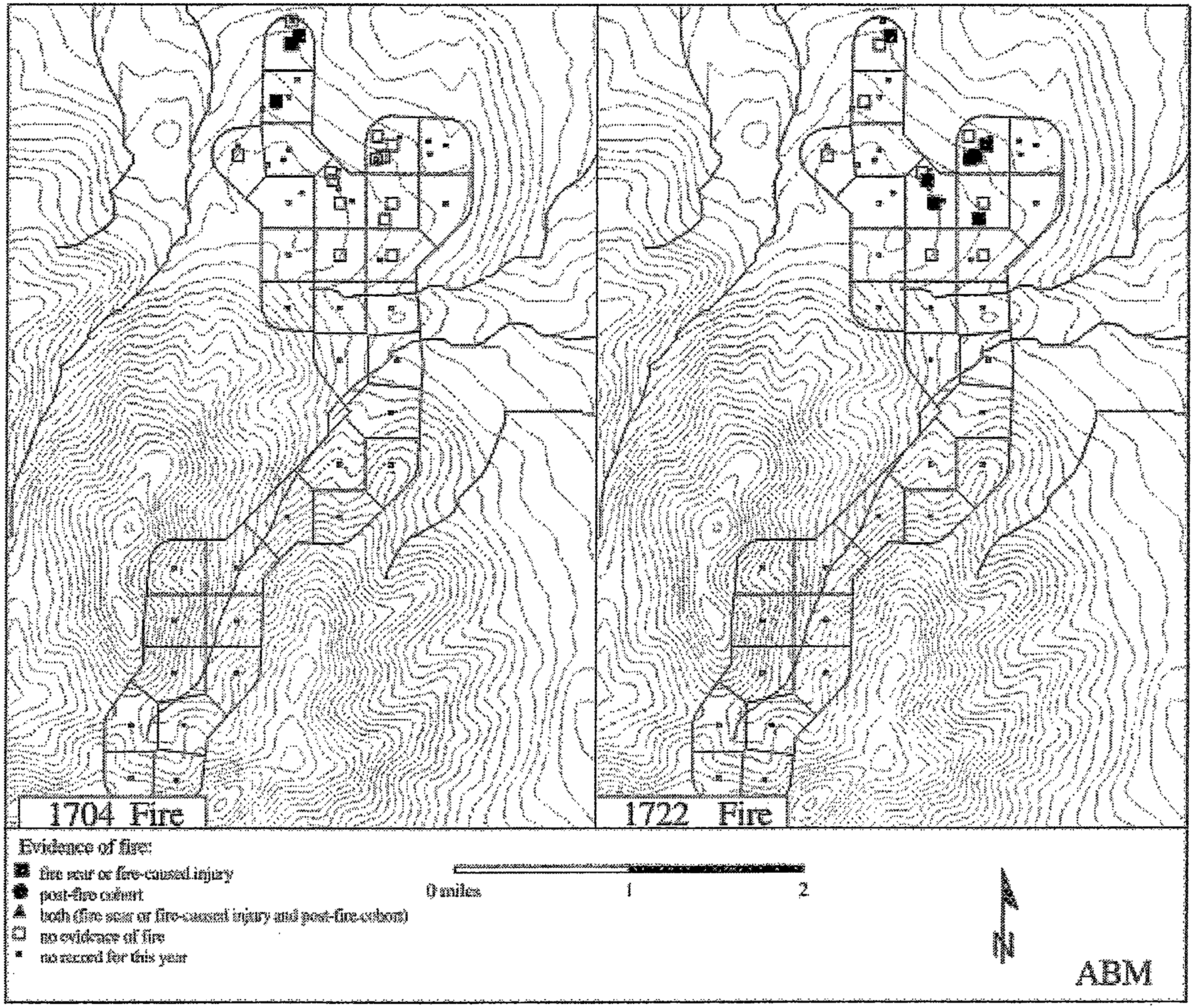
Maps of surface fires at ABM

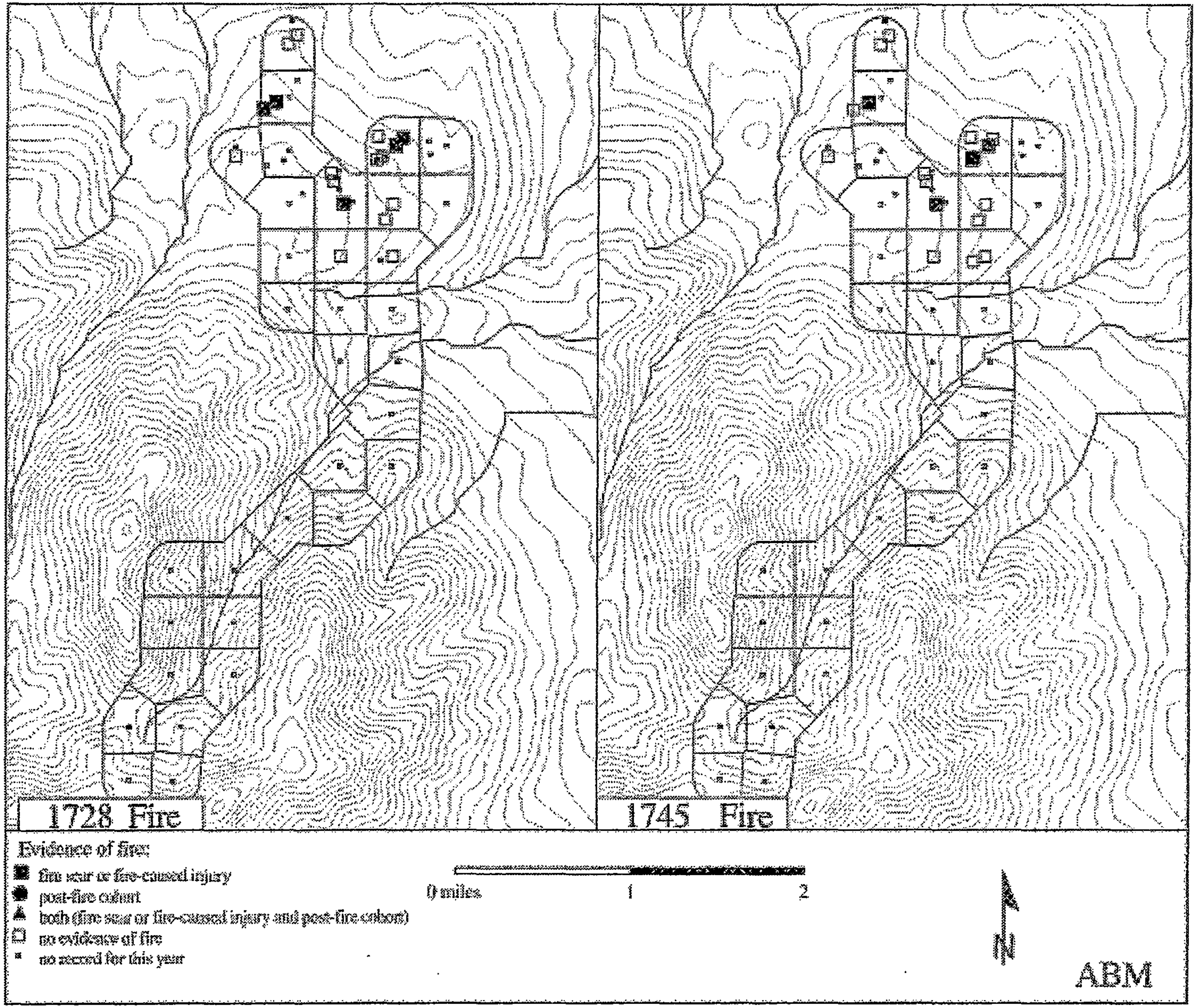
The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.

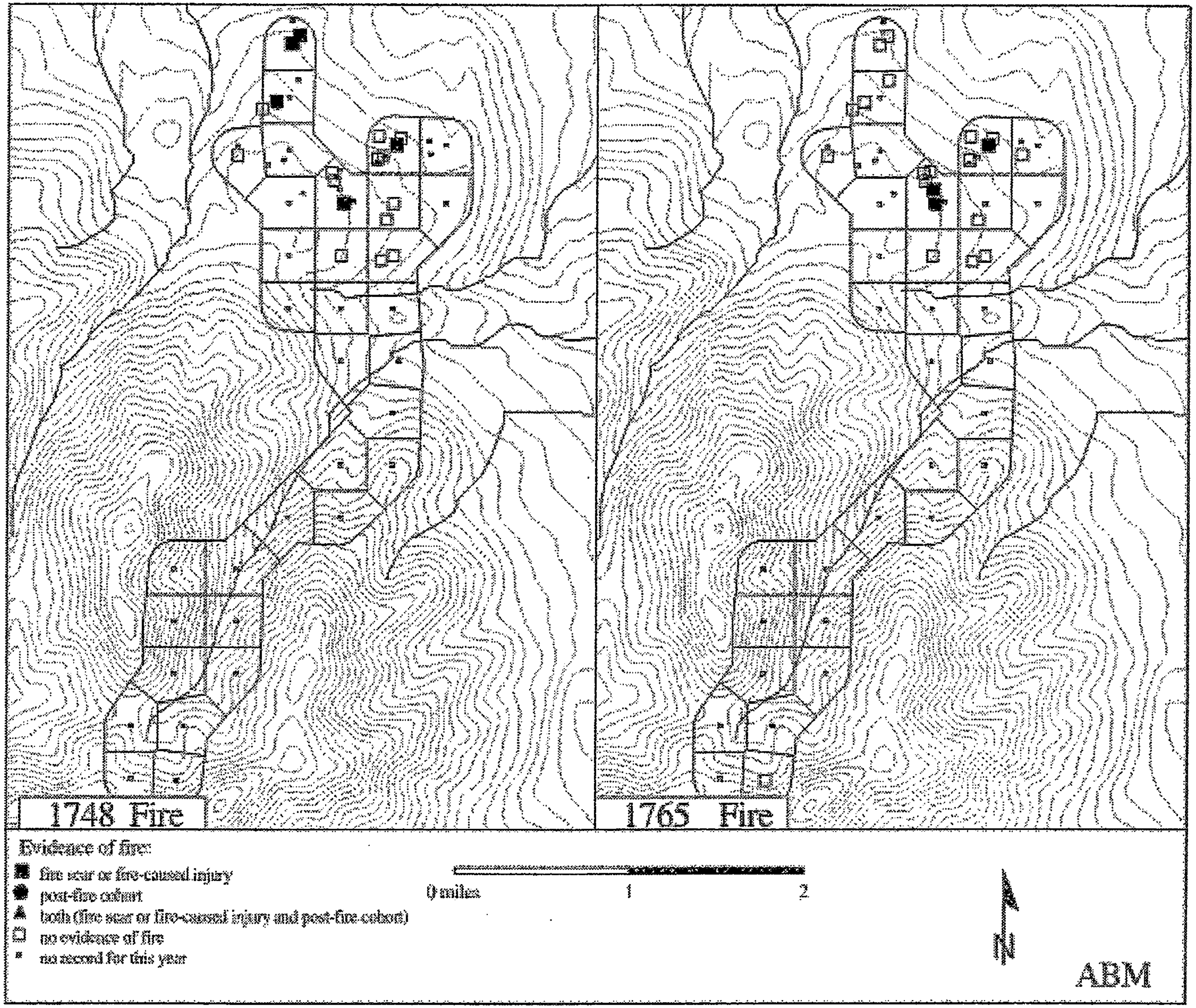

1434 Fire
1579 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
ABM

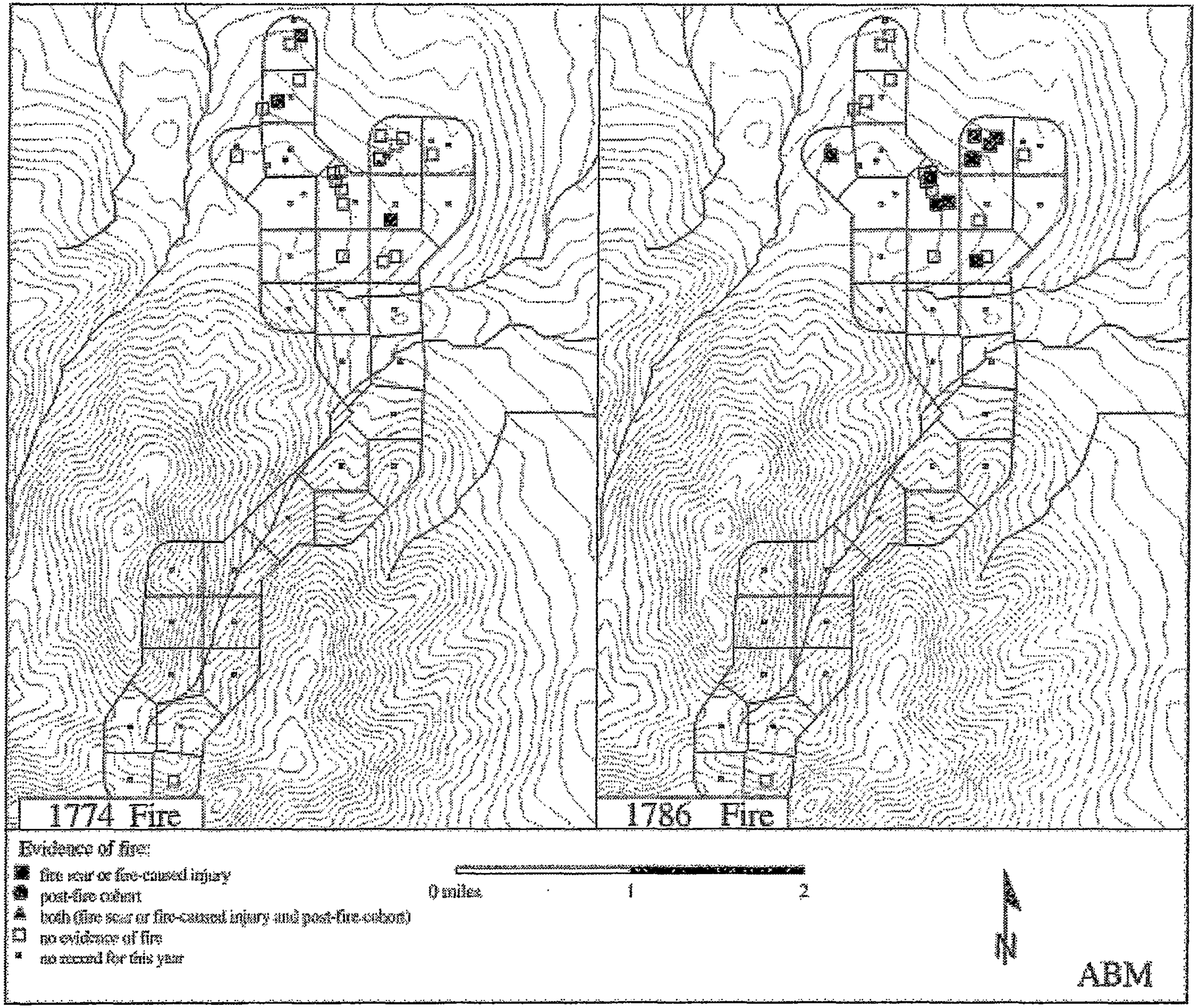

1624 Fire
1652 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
ABM

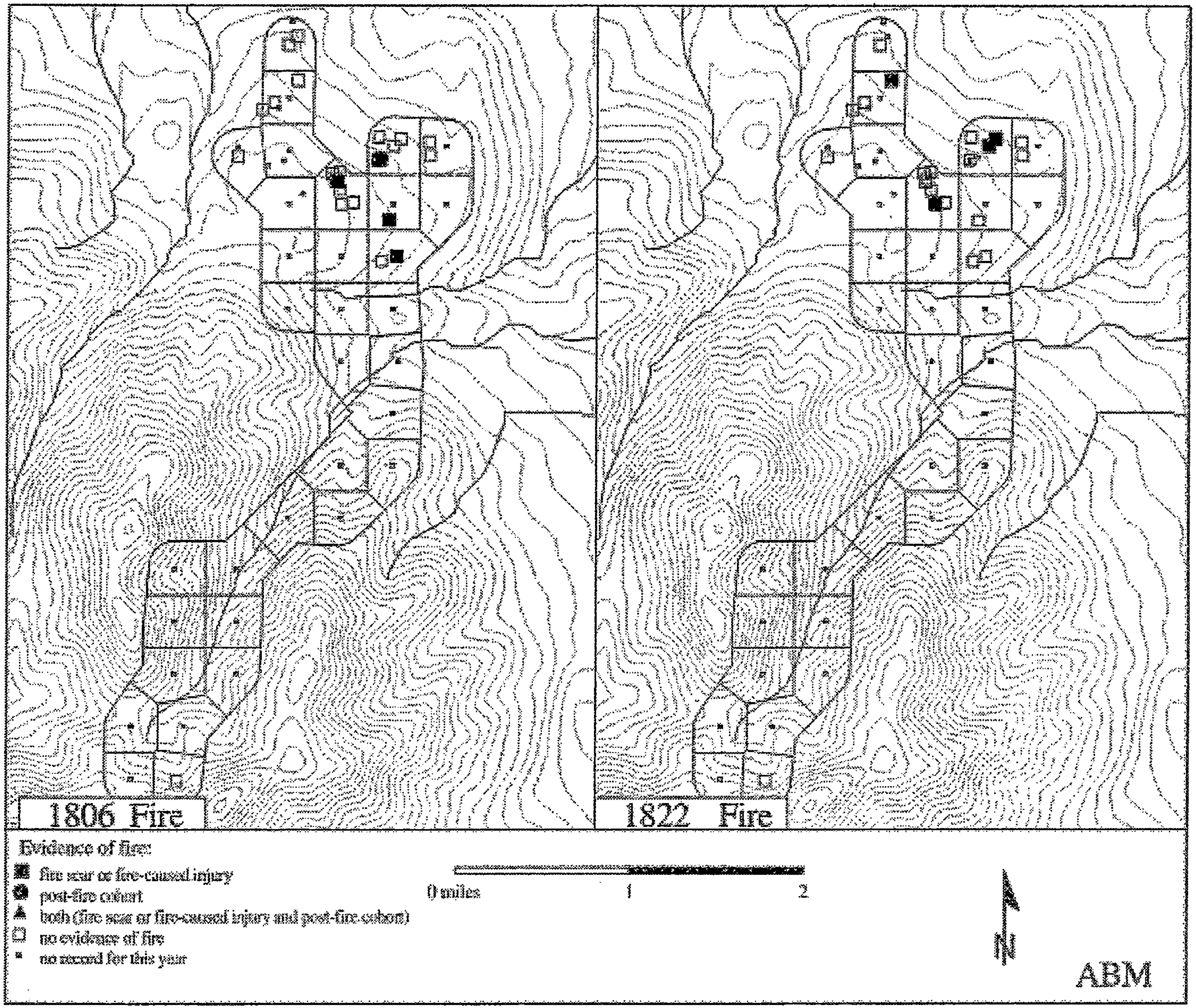

1685 Fire
1697 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
ABM

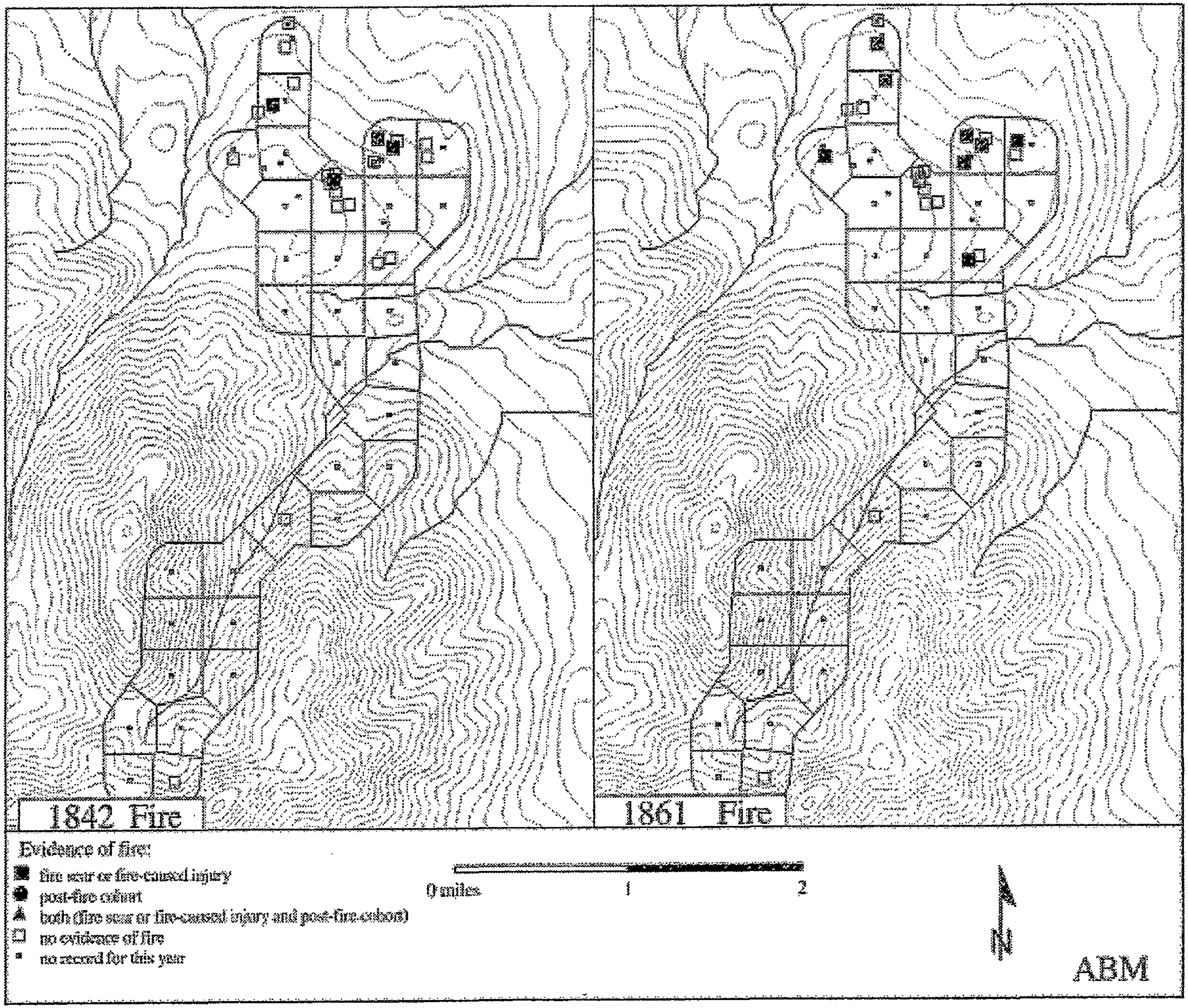

1704 Fire
1722 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
ABM

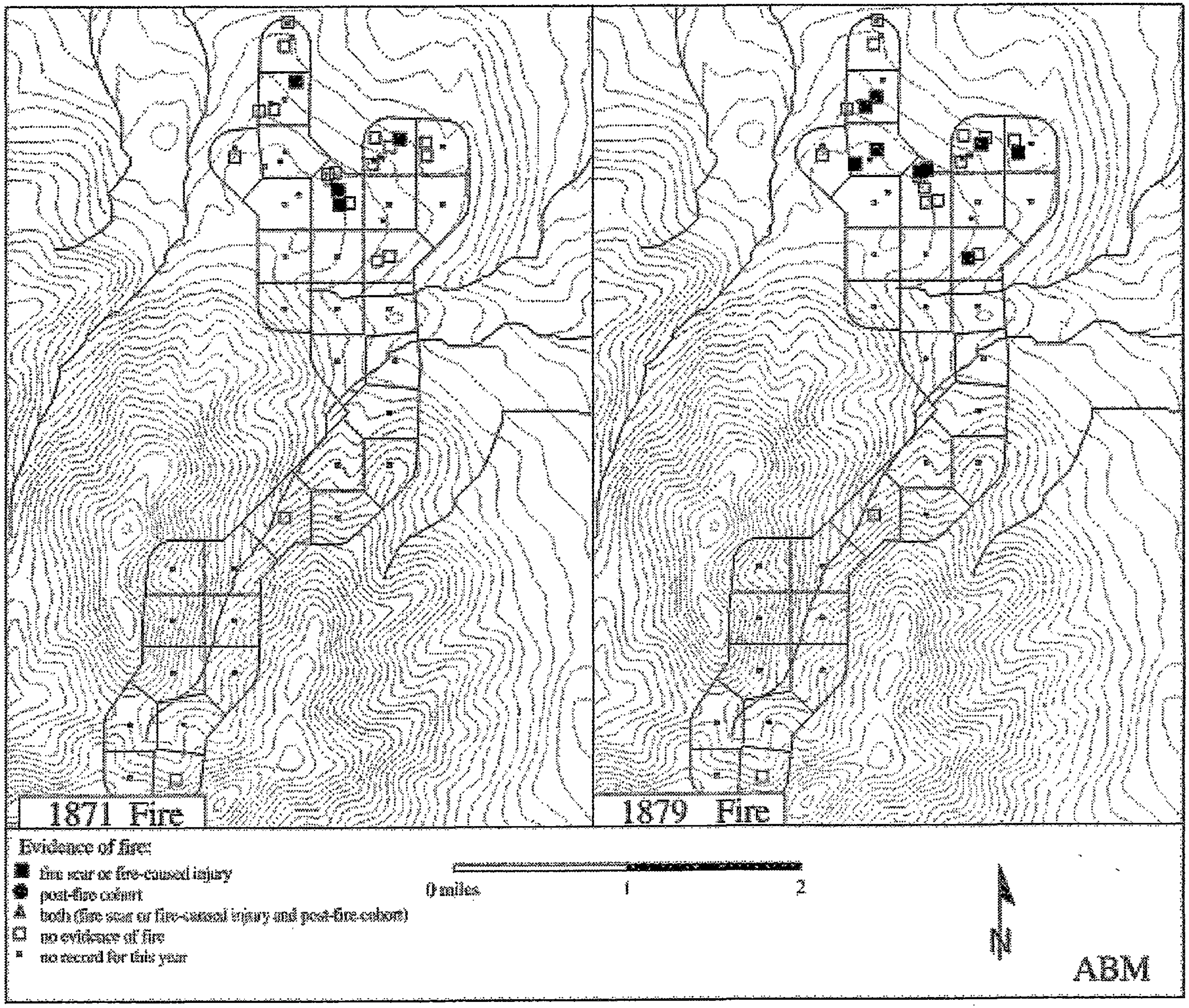

1728 Fire
1745 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
ABM


1748 Fire
1765 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
ABM


1774 Fire
1786 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
ABM


1806 Fire
1822 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
ABM


1842 Fire
1861 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
ABM


1871 Fire
1879 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
ABM

Tushar Mountains - Fishlake National Forest (RBC)

Study Area

We sampled a grid of 44 plots on both sides of the South Fork of the Beaver River, on the Beaver Ranger District of the Fishlake National Forest in Beaver county, Utah (Figure 70). The plots ranged in elevation from 7737 to 10098 ft (average 9136 ft). Slope at the plots ranged from 2-56% (average: 27%), and the plots were sampled on a range of aspects, although most plots were on north or east aspects (70%, Figure 71). The topography of the plots we sampled was generally similar to that of the sampling area at this site, except that we undersampled plots on west aspects.

Results

Tree recruitment

Our plots included 1332 total trees (77% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 1059 trees and were able to crossdate most of these (877 trees, or 83% of sampled trees). The trees that occurred on our plots included a range of species (Figure 72). Trees were recruited into the sampled plots between 1535 and 1955, although most trees (80%) were recruited after 1832 (Figure 73).

Average tree density was higher at plots in 2000 than in 1860 for all 5 of the forest types that we assigned to the sampled plots at this site (ponderosa, mixed conifer, aspen-mixed conifer, aspen and spruce-fir, Figure 74, Table 2).

Surface fires

We removed fire-scarred sections from a total of 167 trees at RBC. We sampled almost half of these (68%) in the 16 of our 44 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were ponderosa pine (40%), Douglas-fir (36%) or Engelmann spruce (15%), but we also sampled a few fire-scarred white fir, subalpine fir and aspen. Most of the trees we sampled were logs, snags or stumps (67%), with the rest live trees. We were unable to crossdate sections from some of the sampled trees (14%). Those that we did crossdate yielded 619 fire scars, and 51 eroded fire scars or abrupt changes in ring width (1451 to 2002; Figure 75). We were able to assign an intra-ring position to 70% of the fire scars. Most of the scars from the analysis period (1650-1900) were created by fires burning when the cambium was growing (70% of assigned scars, Figure 76).

The number of surface fires during the analysis period (1650-1900) varied with elevation and forest type at RBC (Figure 77), with fires more frequent at low than high elevation, and in dry versus mesic forest types.

Figures and tables for RBC

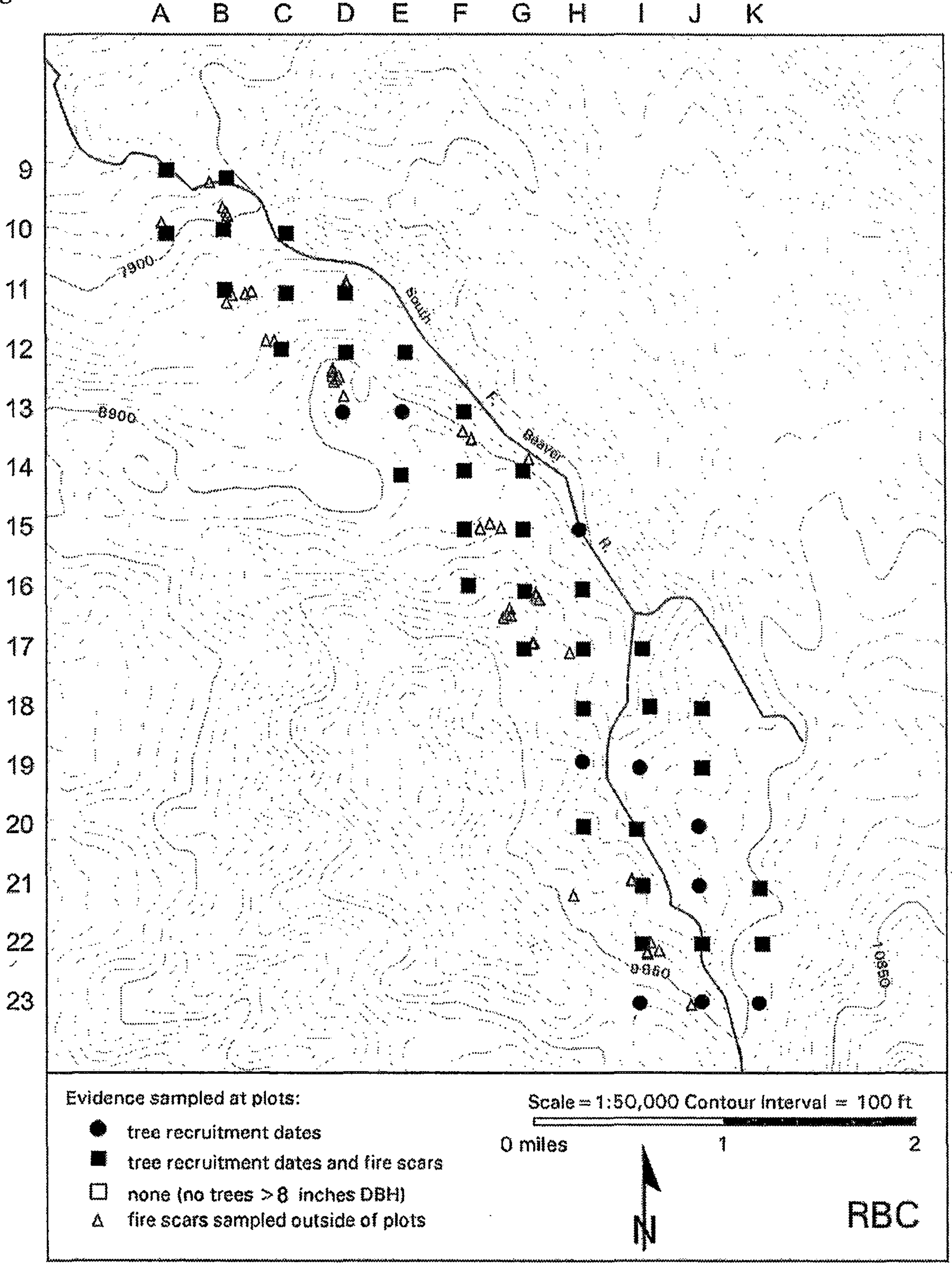


Figure 70. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the northwestern most plot is 9A, the next plot to the east is 9B, etc. Most of the fire-scarred trees (68% of 167 dated trees) were sampled within plots and so are not mapped individually.

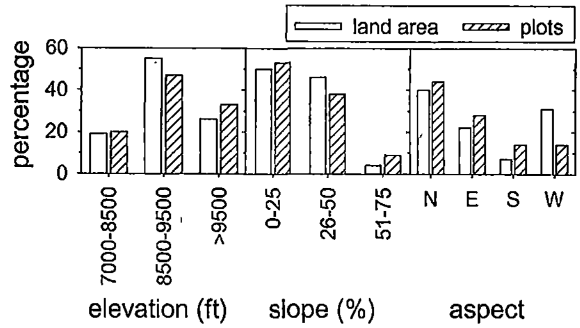


Figure 71. Distribution of topography for sampled plots and for land area at RBC. Aspect classes are 90° wide, beginning with 46° for east (E). Land area was derived from a digital elevation model.

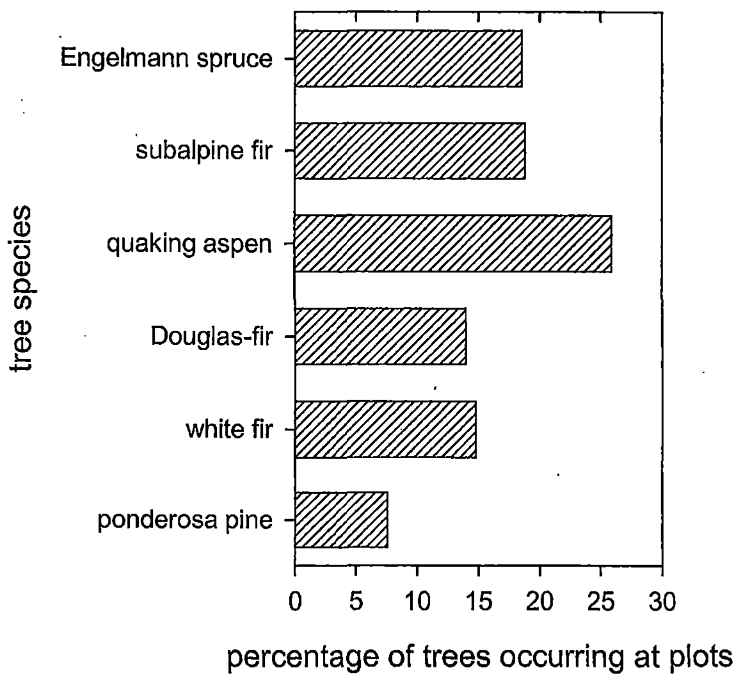


Figure 72. Species distribution of all trees that occurred in plots at RBC.

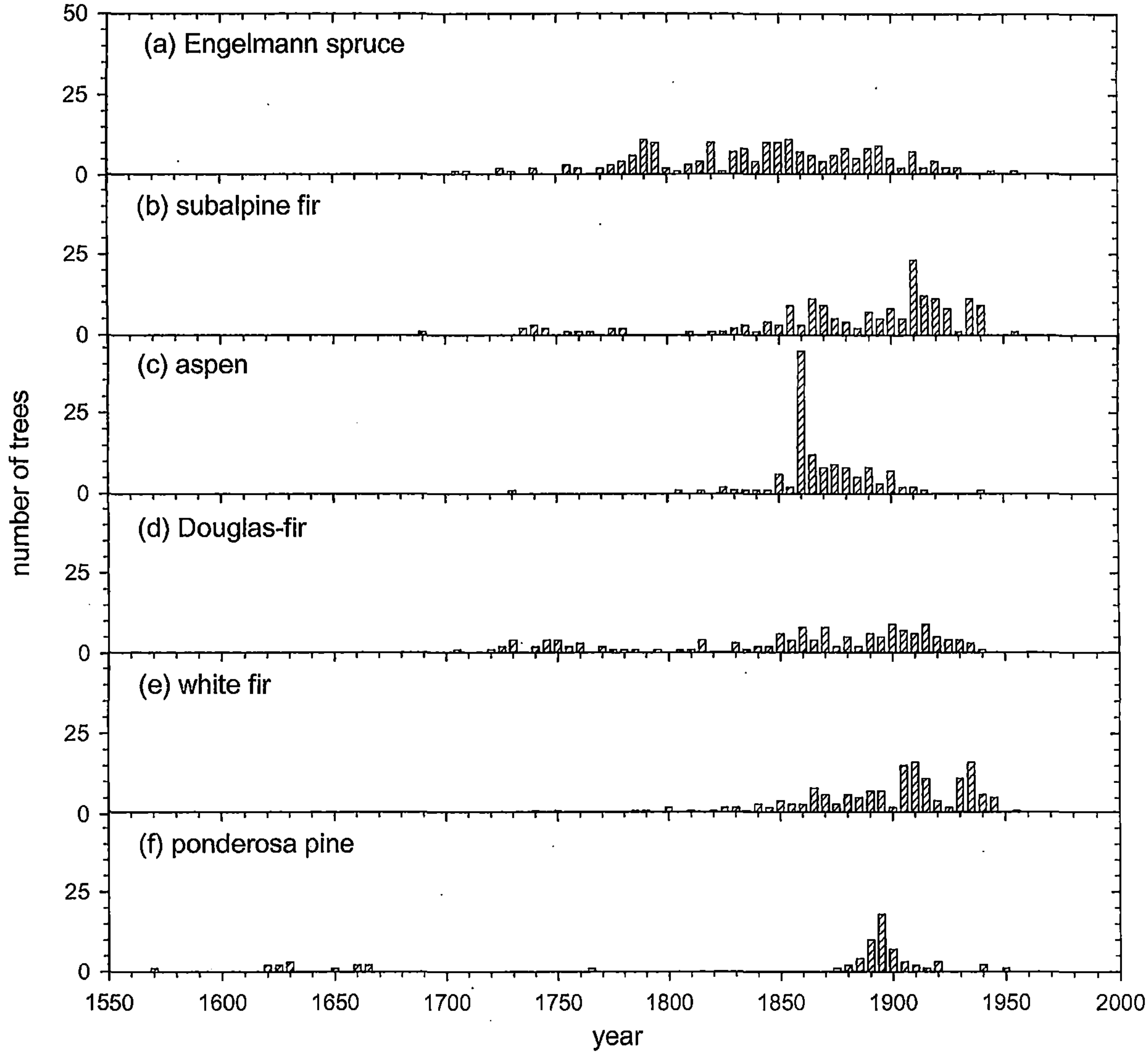


Figure 73. Distribution of tree-recruitment dates by species at RBC, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

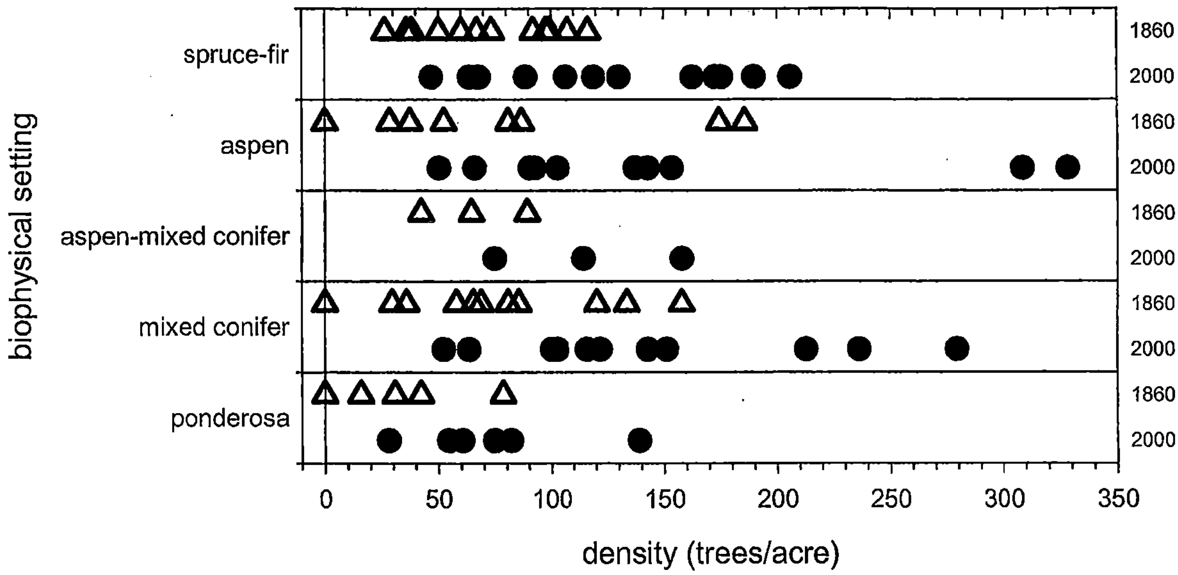


Figure 74. Density of live trees >8 inches DBH at each plot at RBC, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

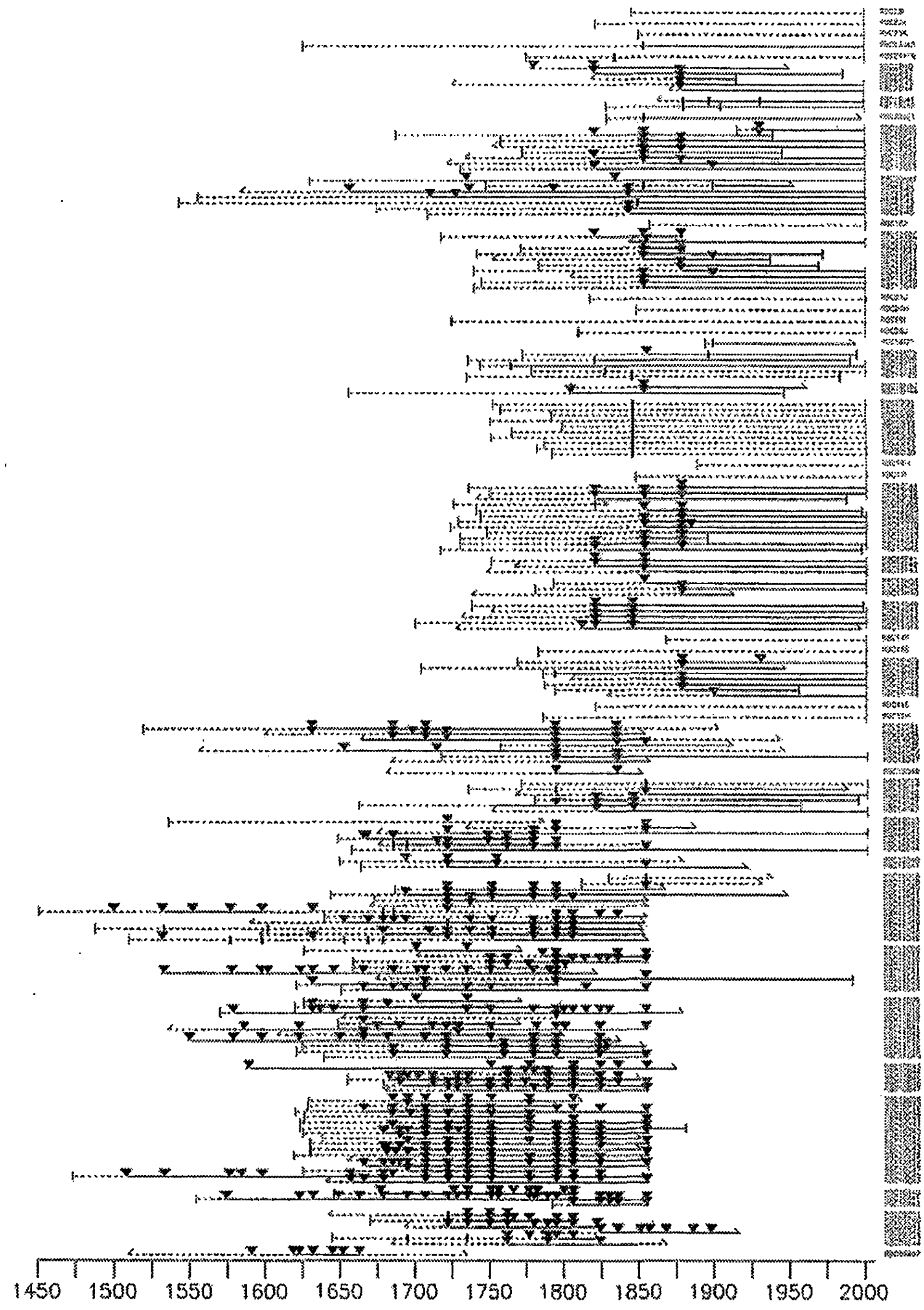


Figure 75. Fire chronologies at RBC, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

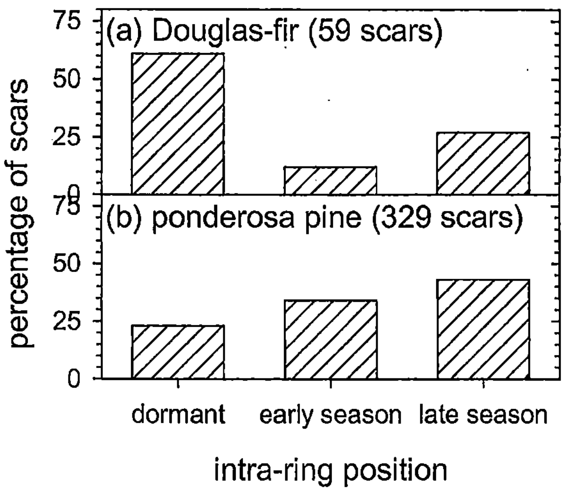


Figure 76. Intra-ring position of fire scars at RBC (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only species that comprised >10% of trees are plotted. We also dated scars from some white fir, subalpine fir, Engelmann spruce and quaking aspen, but these species yielded too few scars with an intra-ring position to plot here.

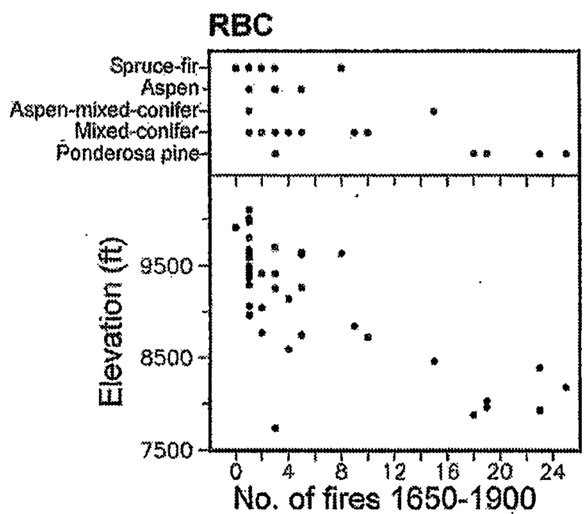
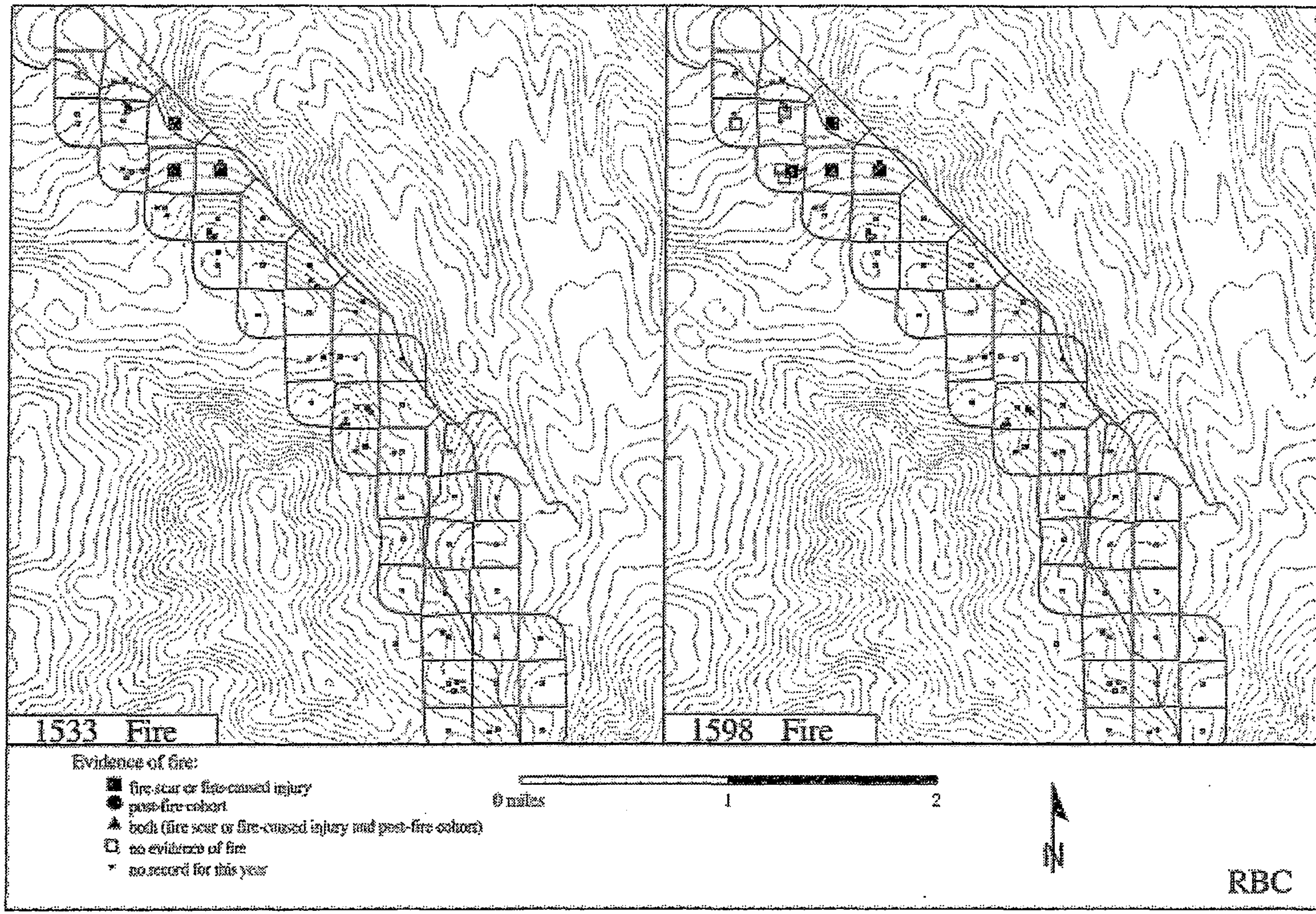
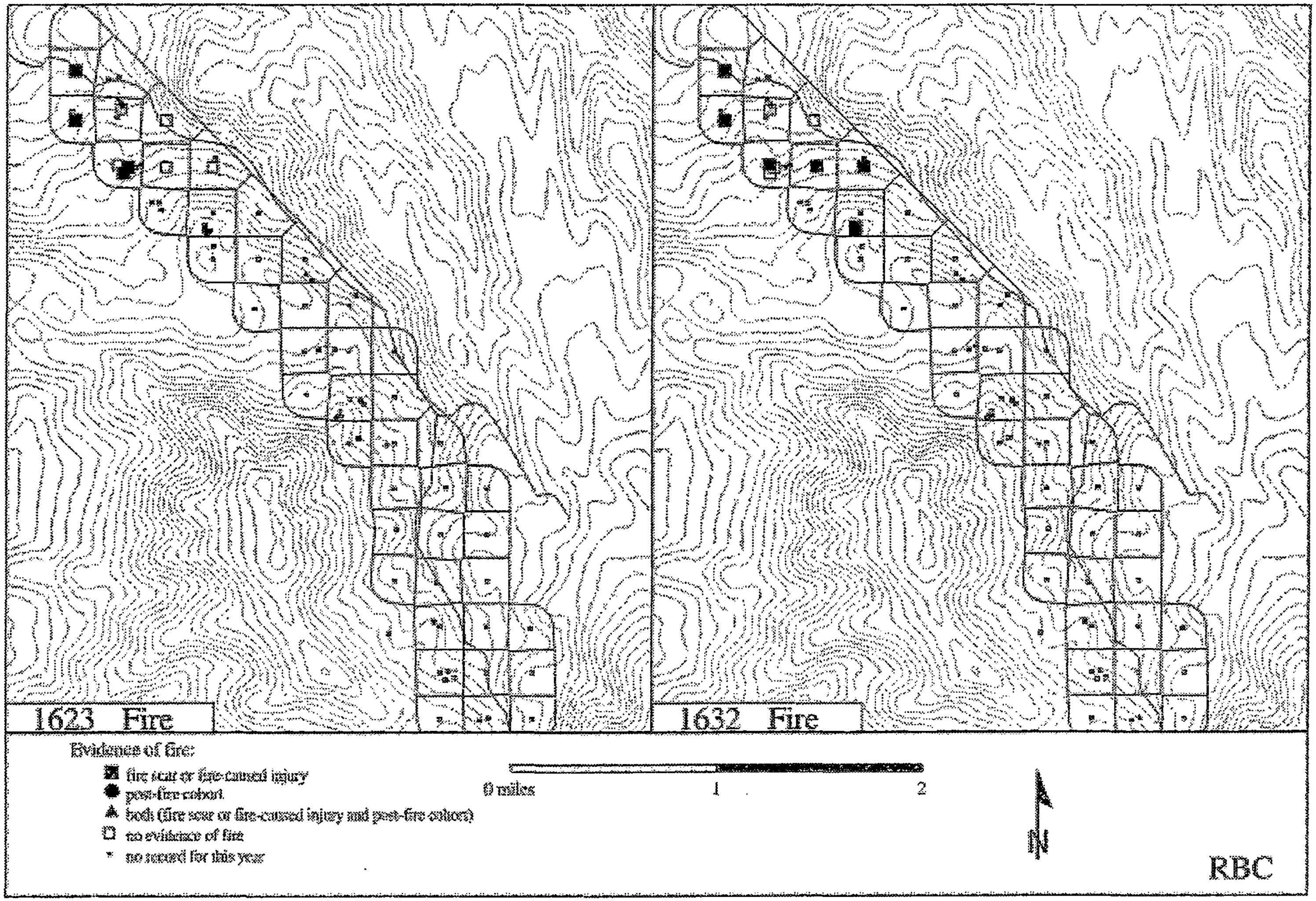


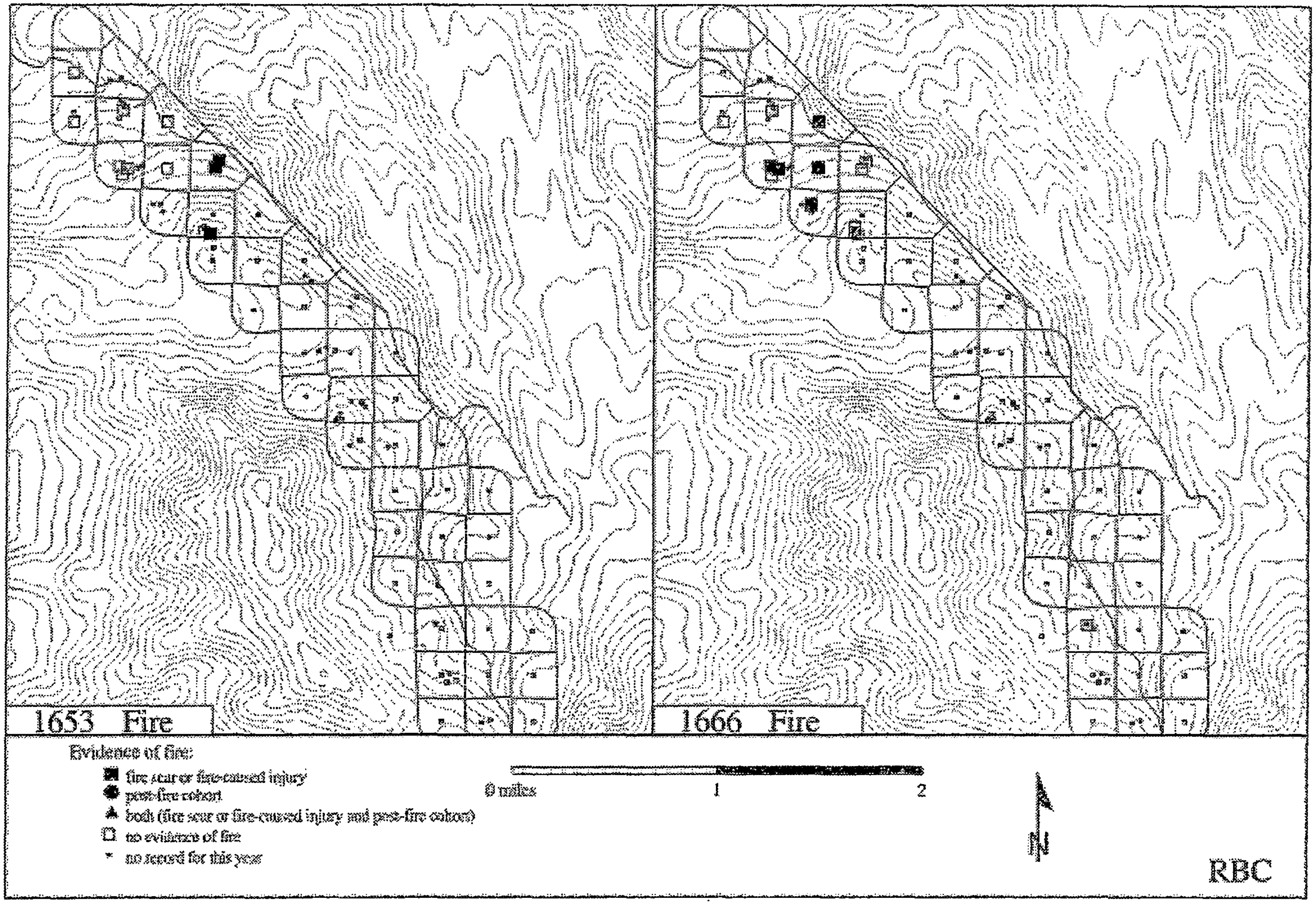
Figure 77. Number of fires within cells at RBC (1650-1900), by forest type (top panel, Table 2) and elevation (bottom panel). Number of fires includes only those fire years which were recorded on ≥2 trees at a site.

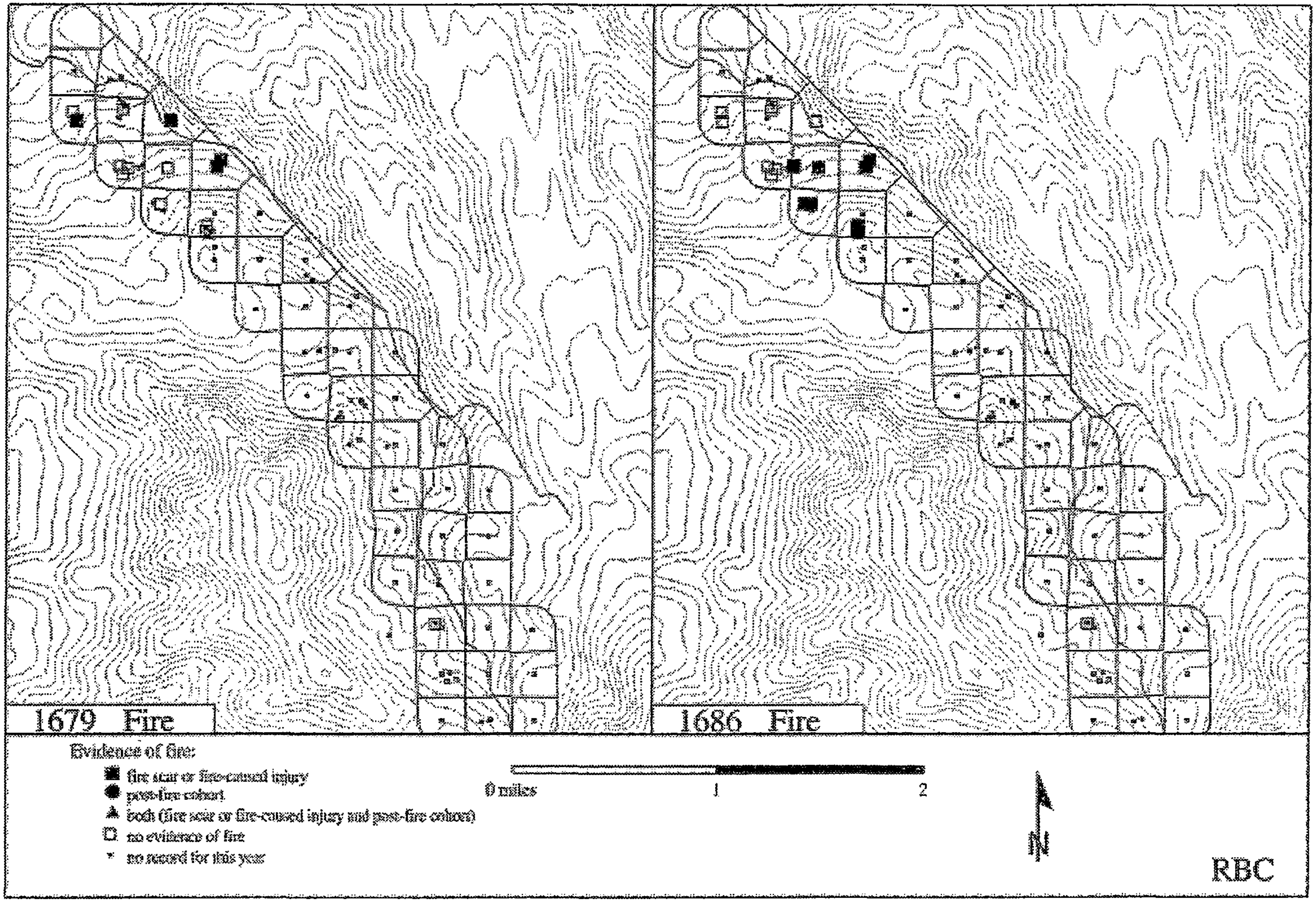
Maps of surface fires at RBC

The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.

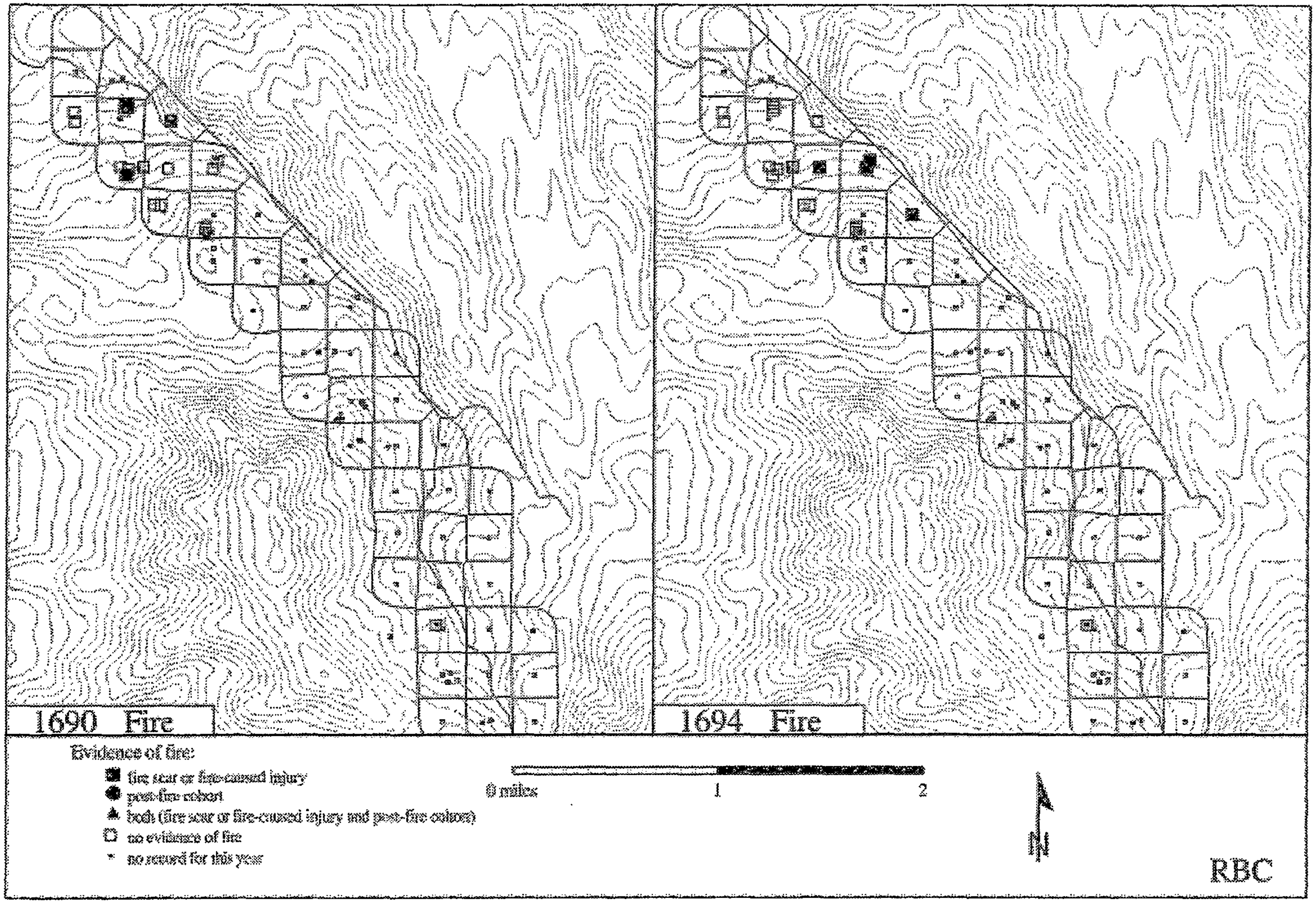

1533 Fire
1598 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC

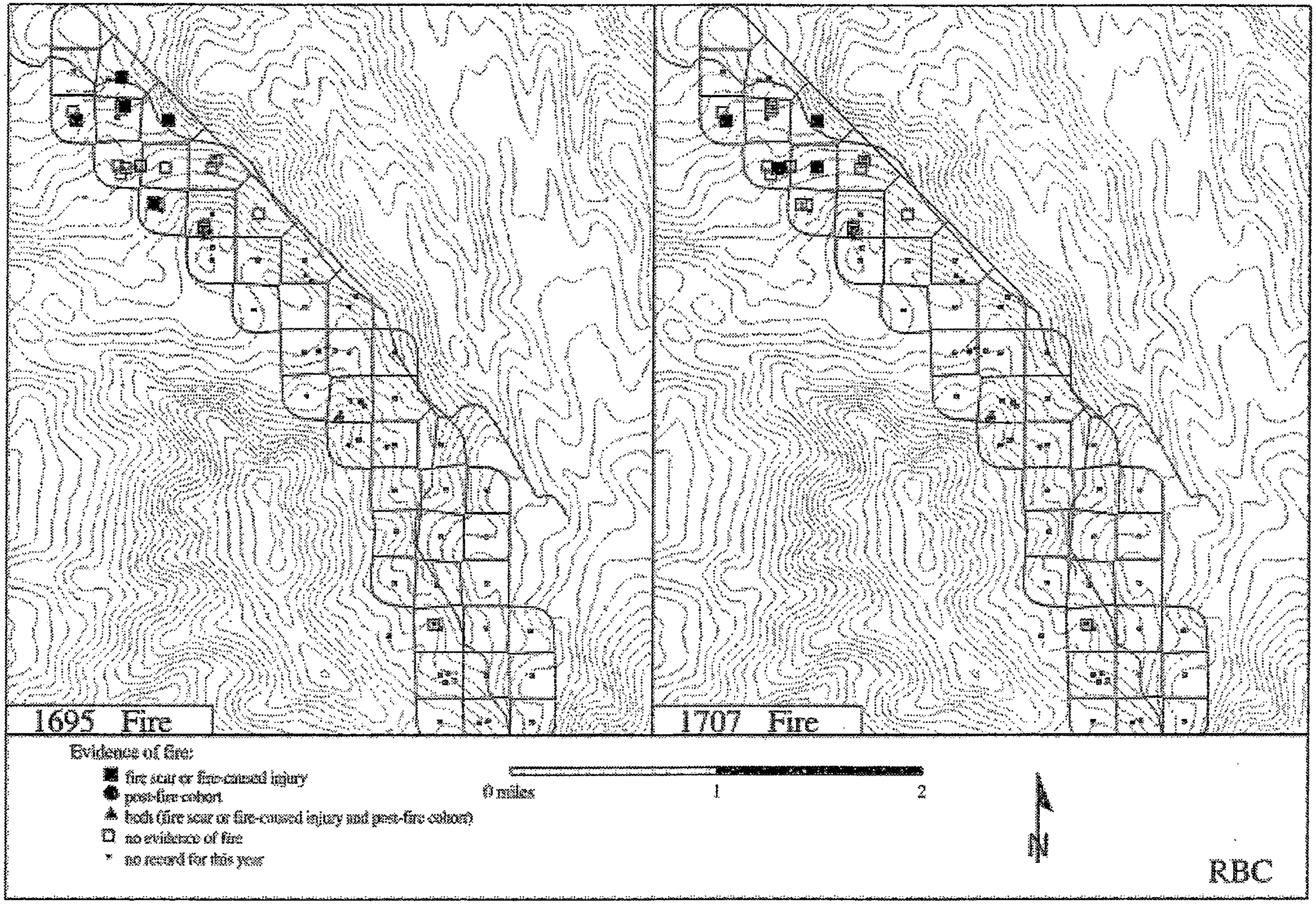

1623 Fire
1632 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC

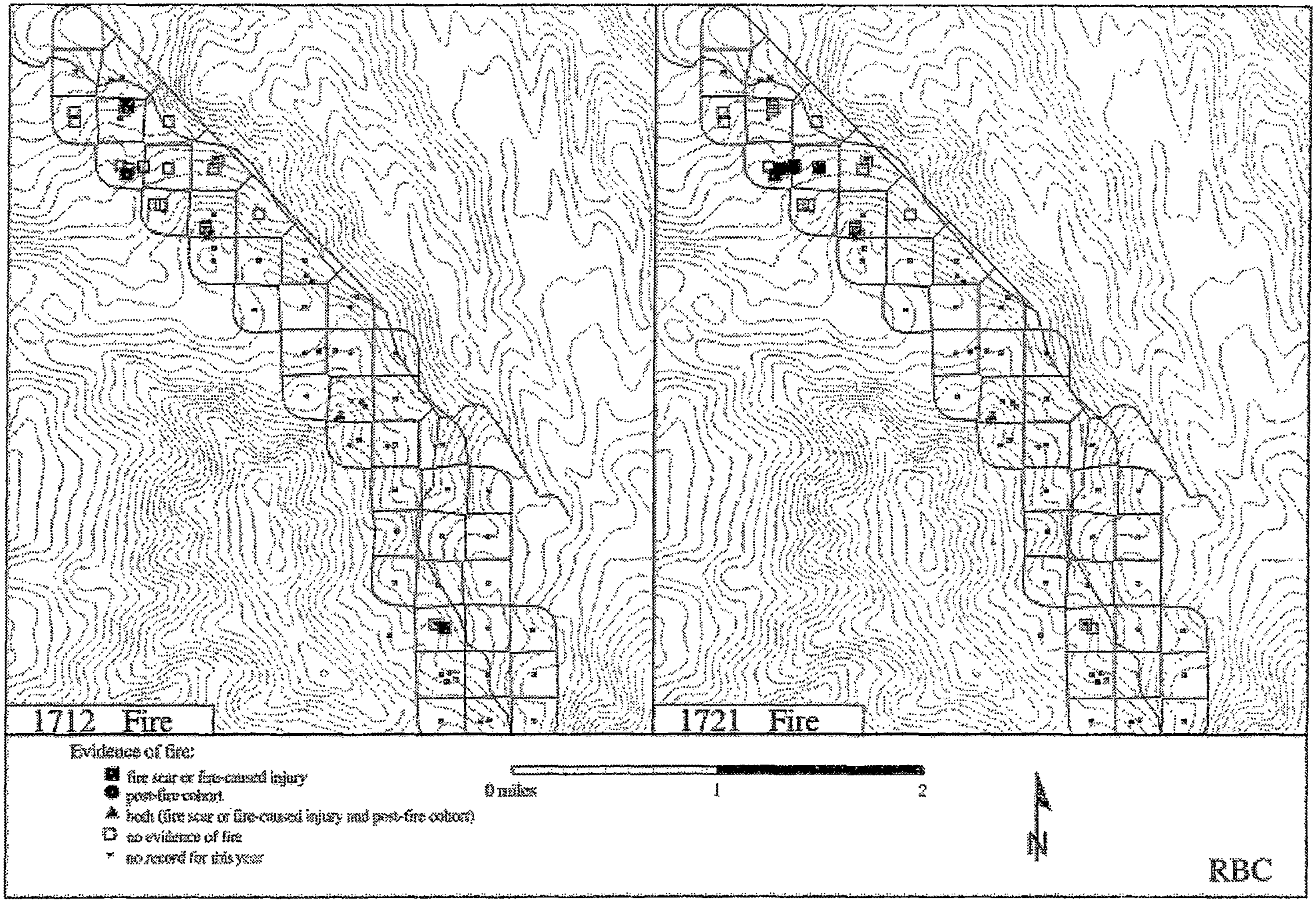

1653 Fire
1666 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC



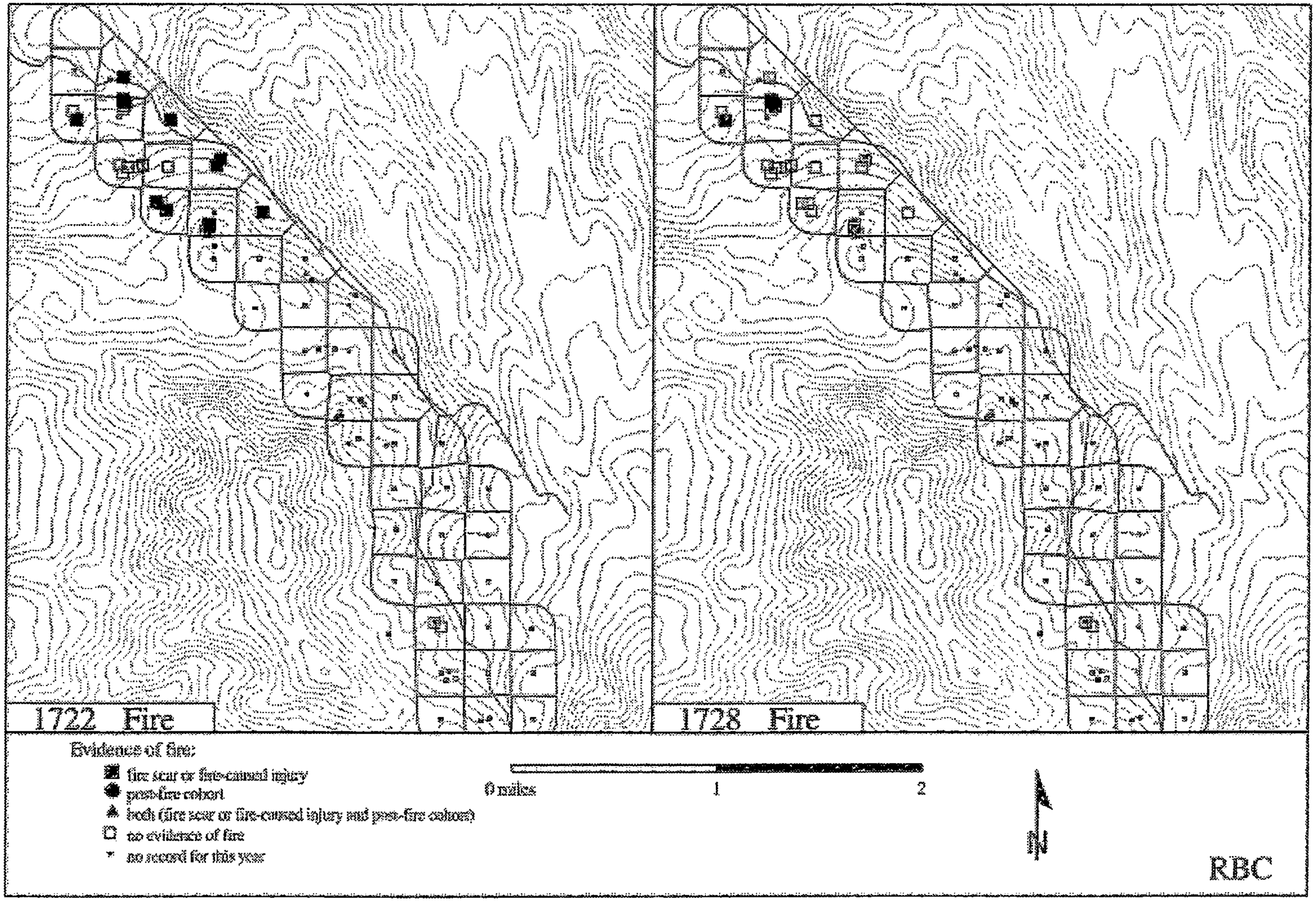
1679 Fire
1686 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC

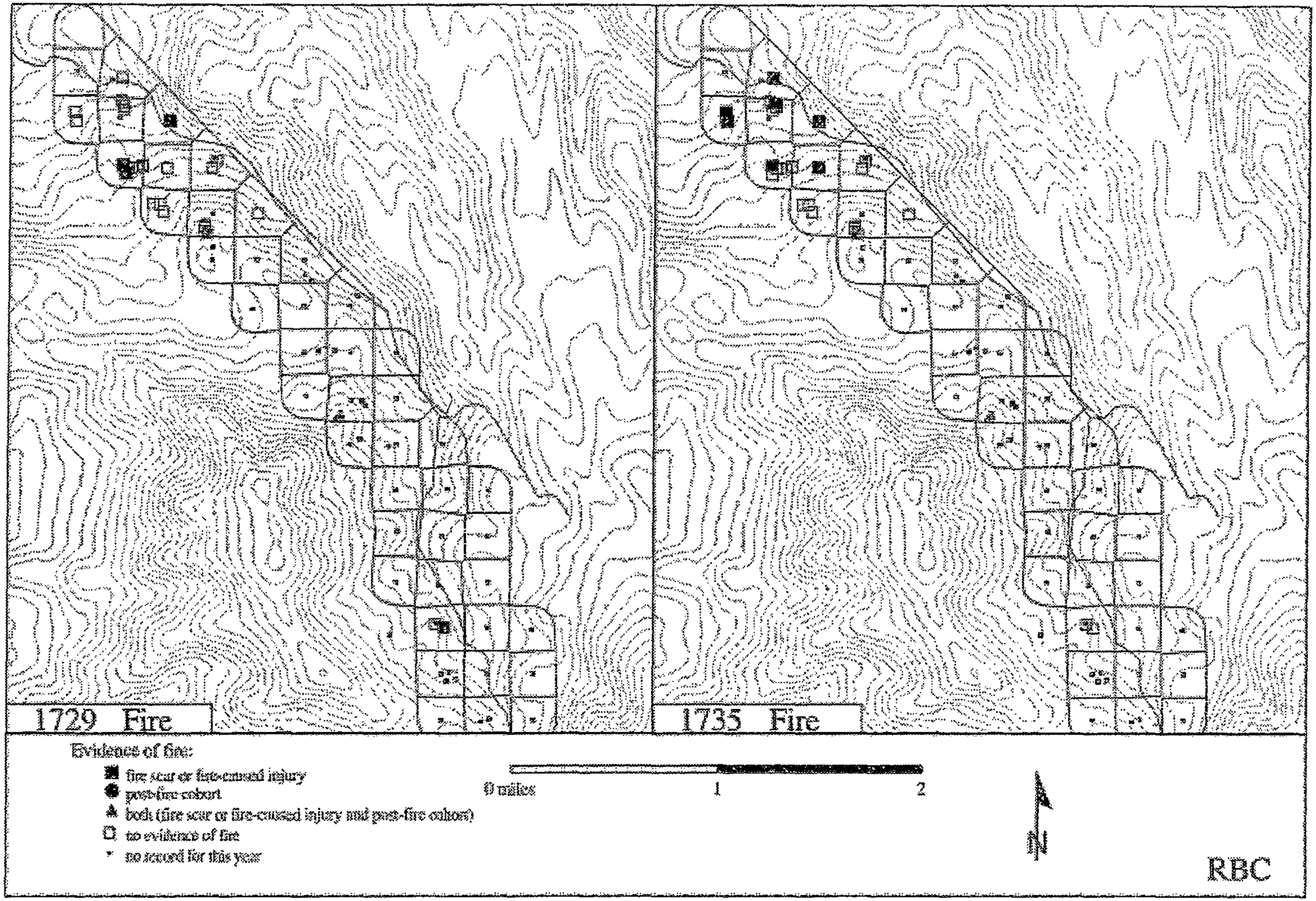

1690 Fire
1694 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC

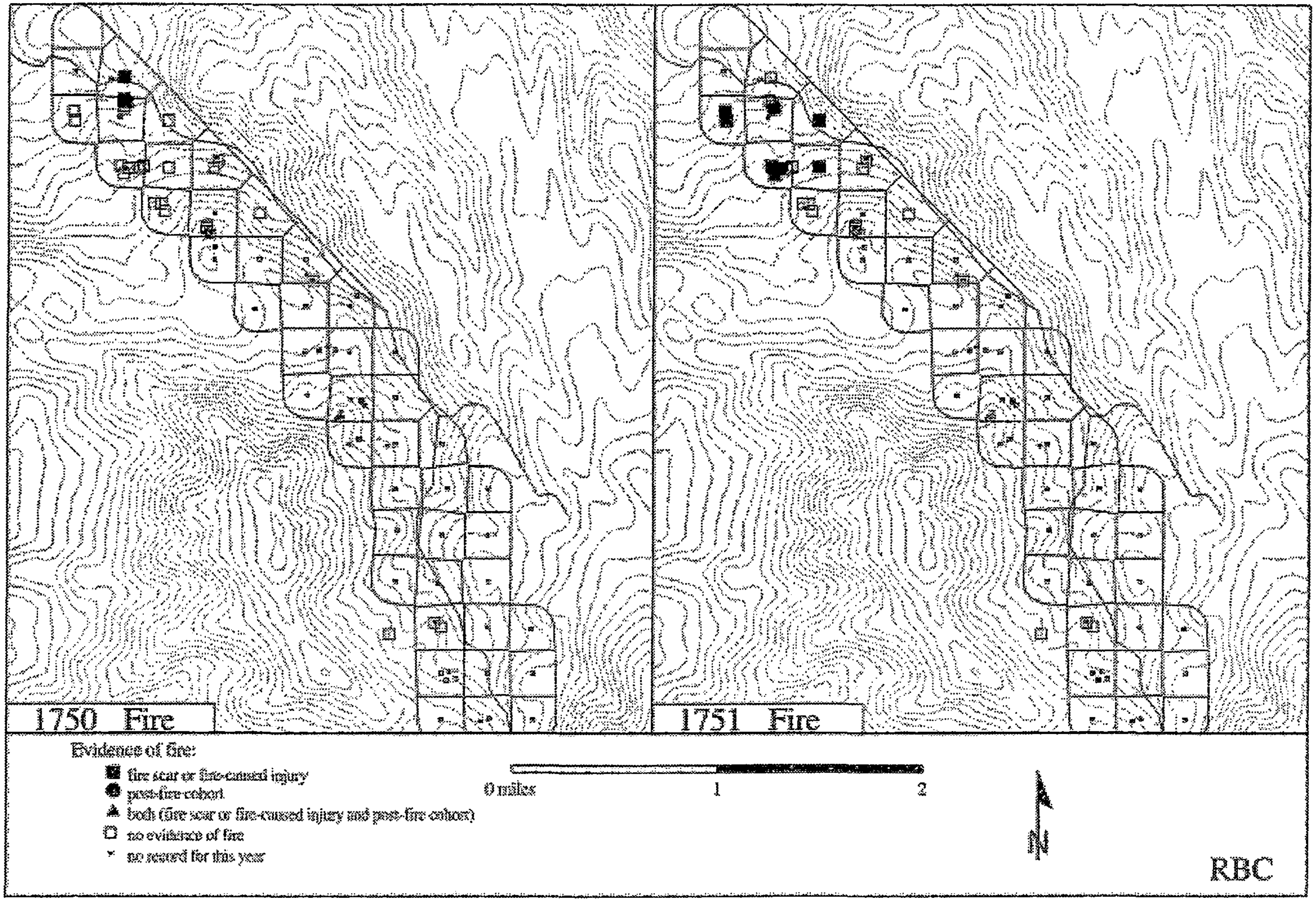

1695 Fire
1707 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC

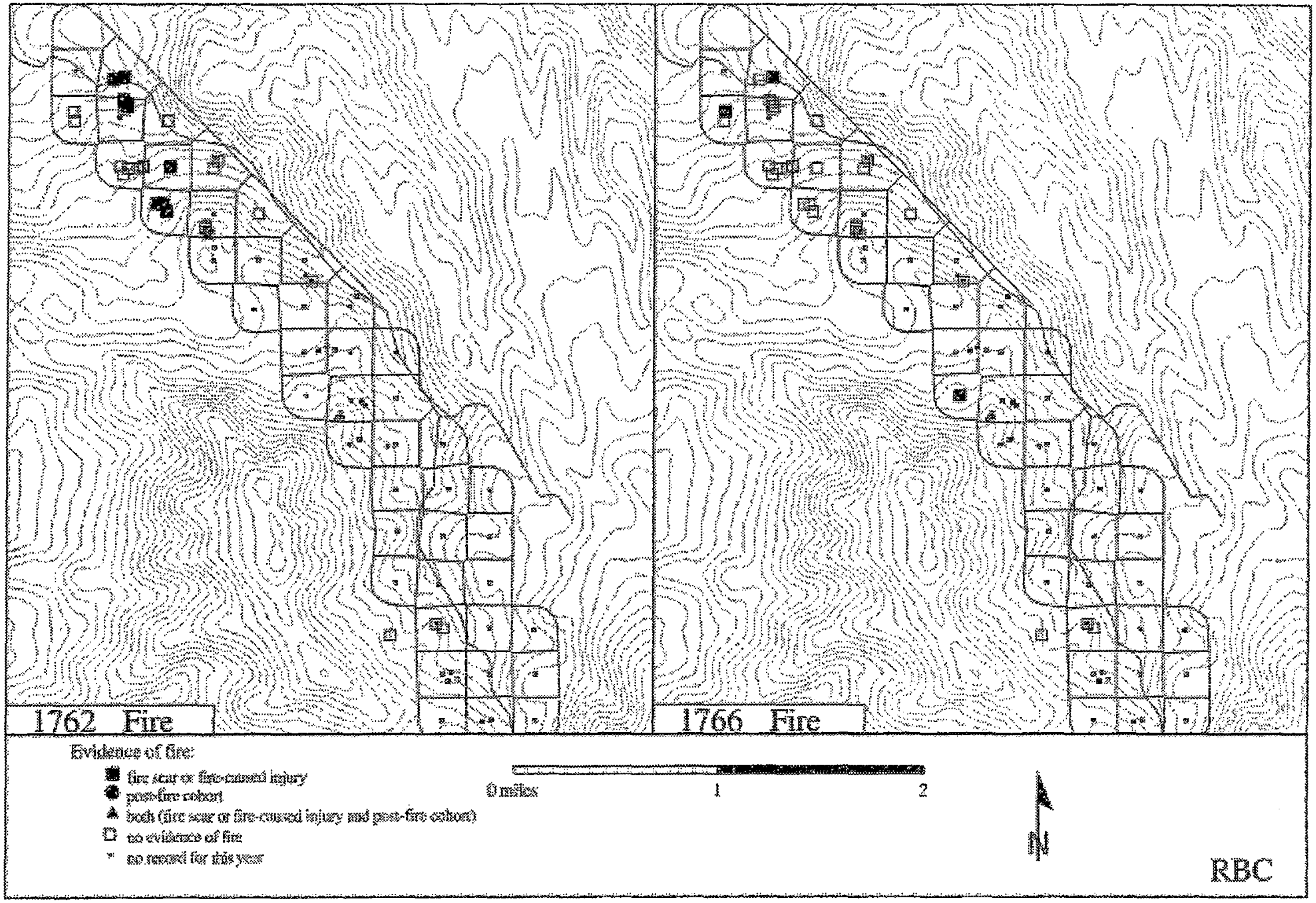


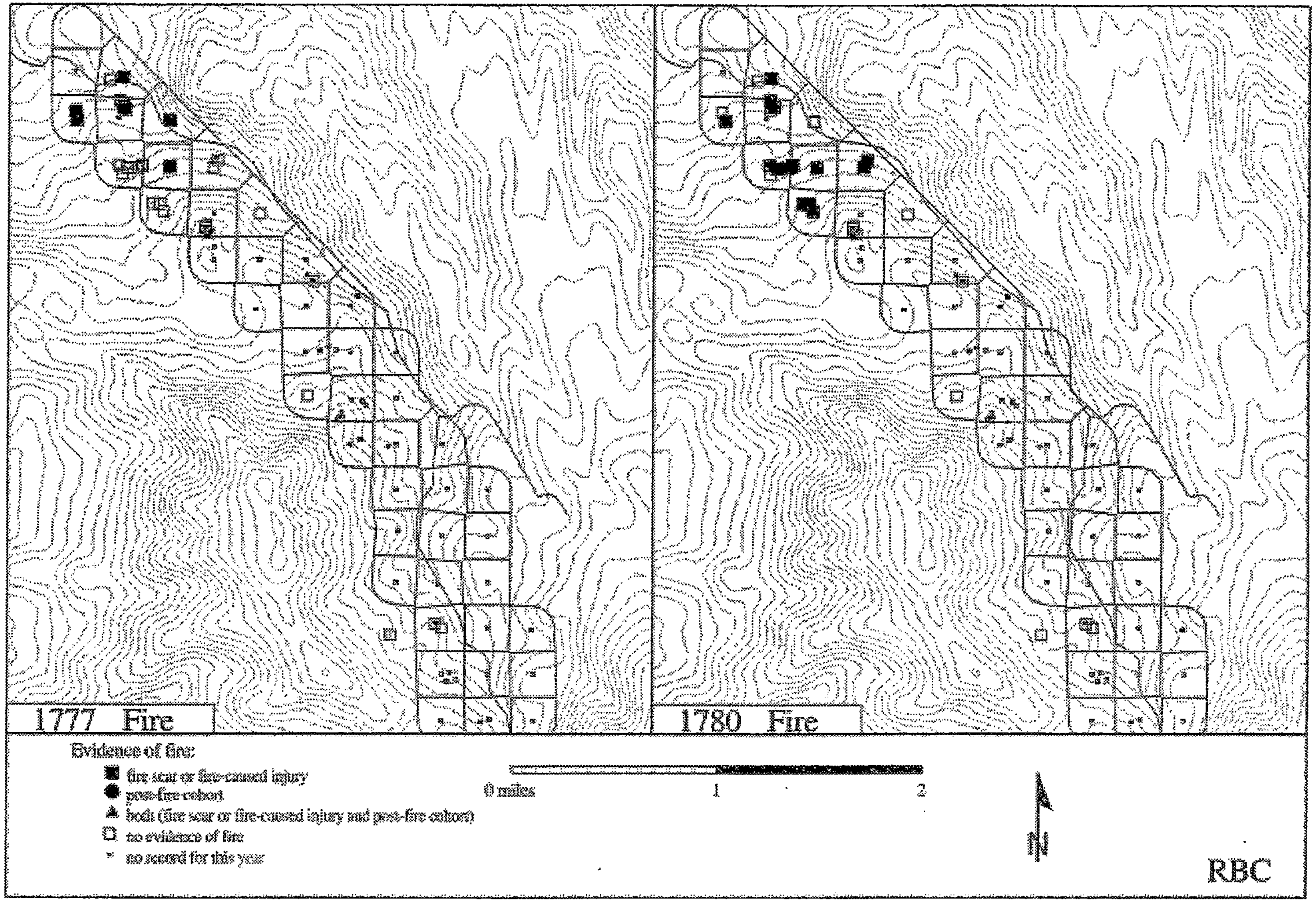
1712 Fire
1721 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC

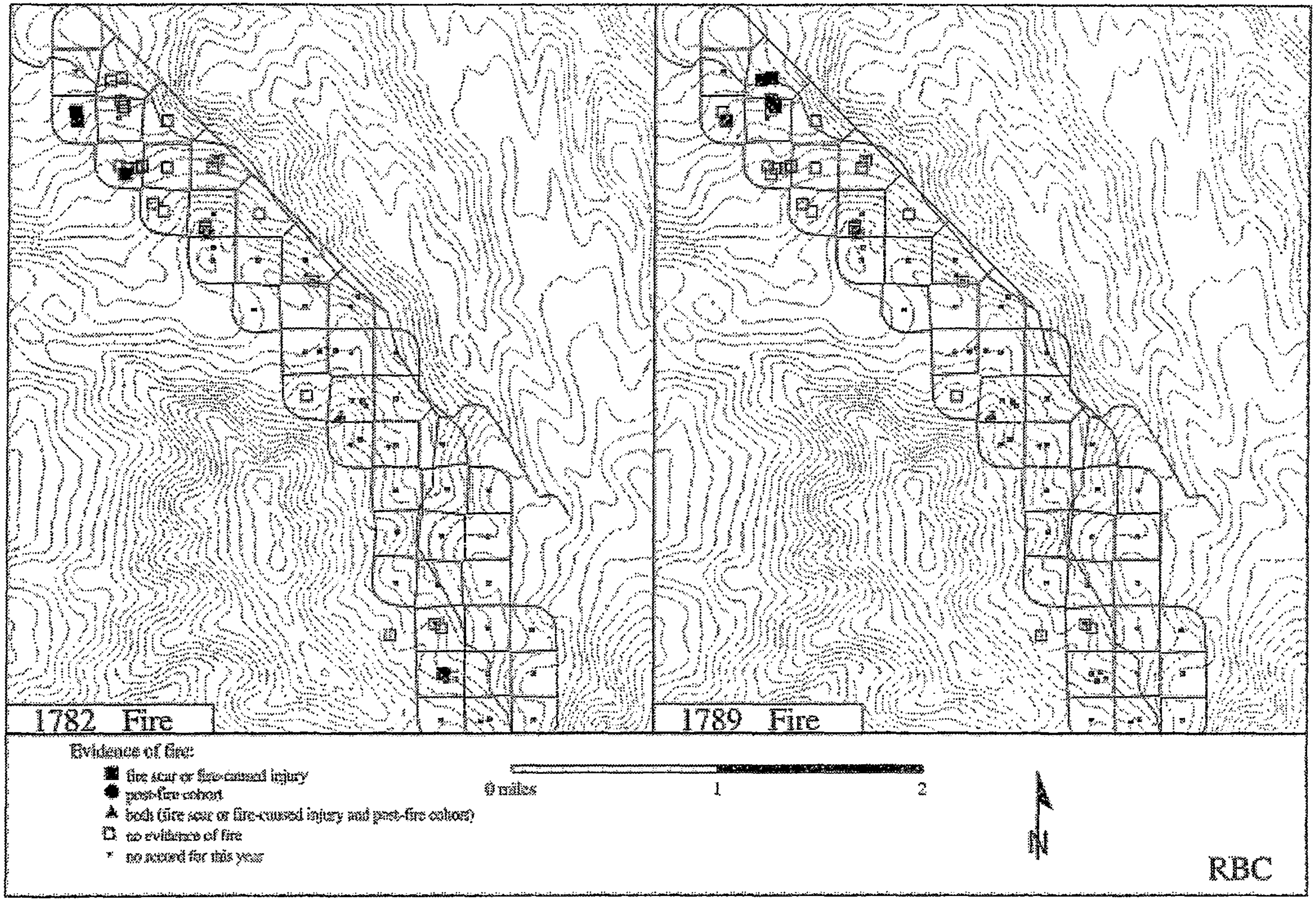

1722 Fire
1728 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC

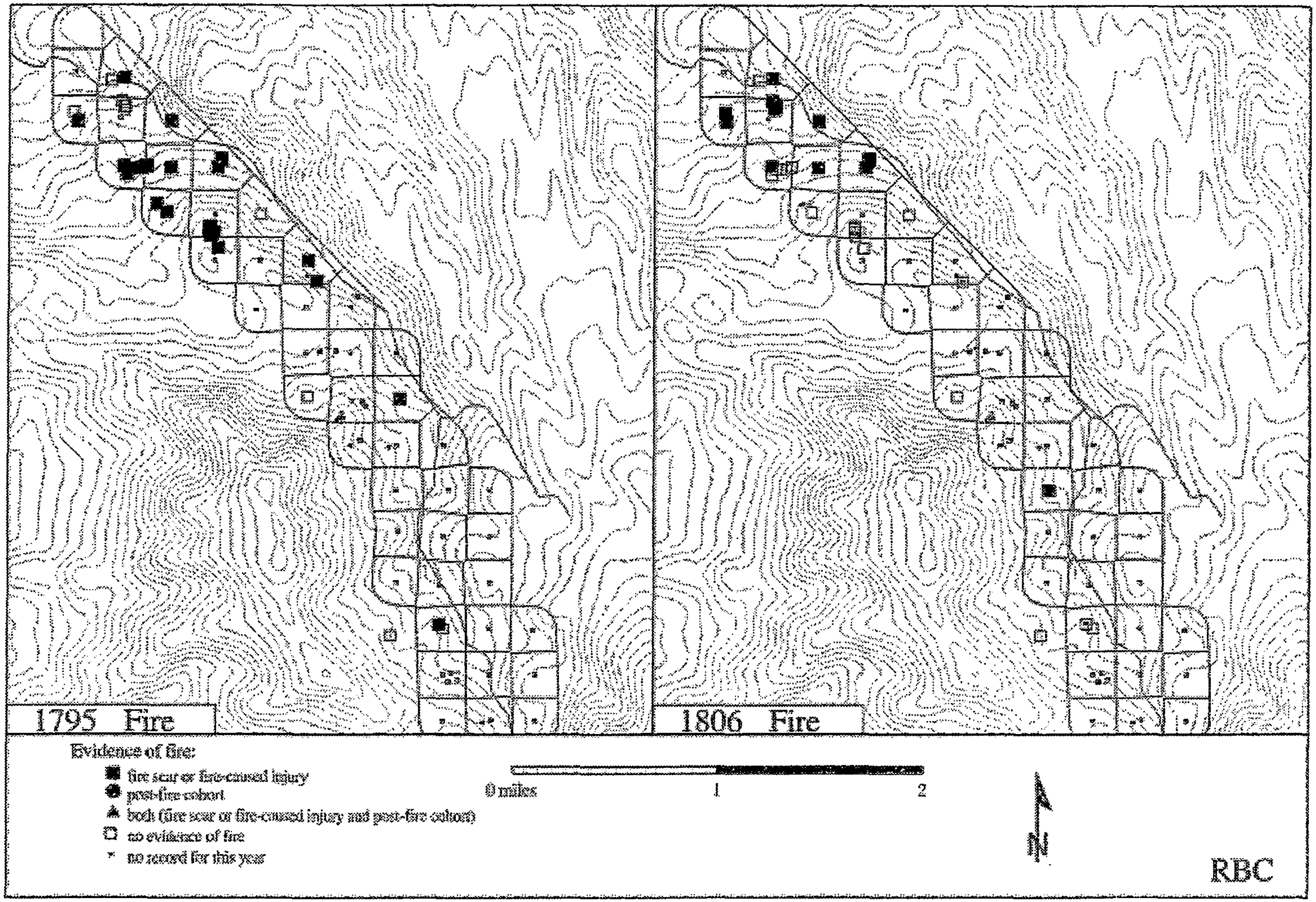

1729 Fire
1735 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC

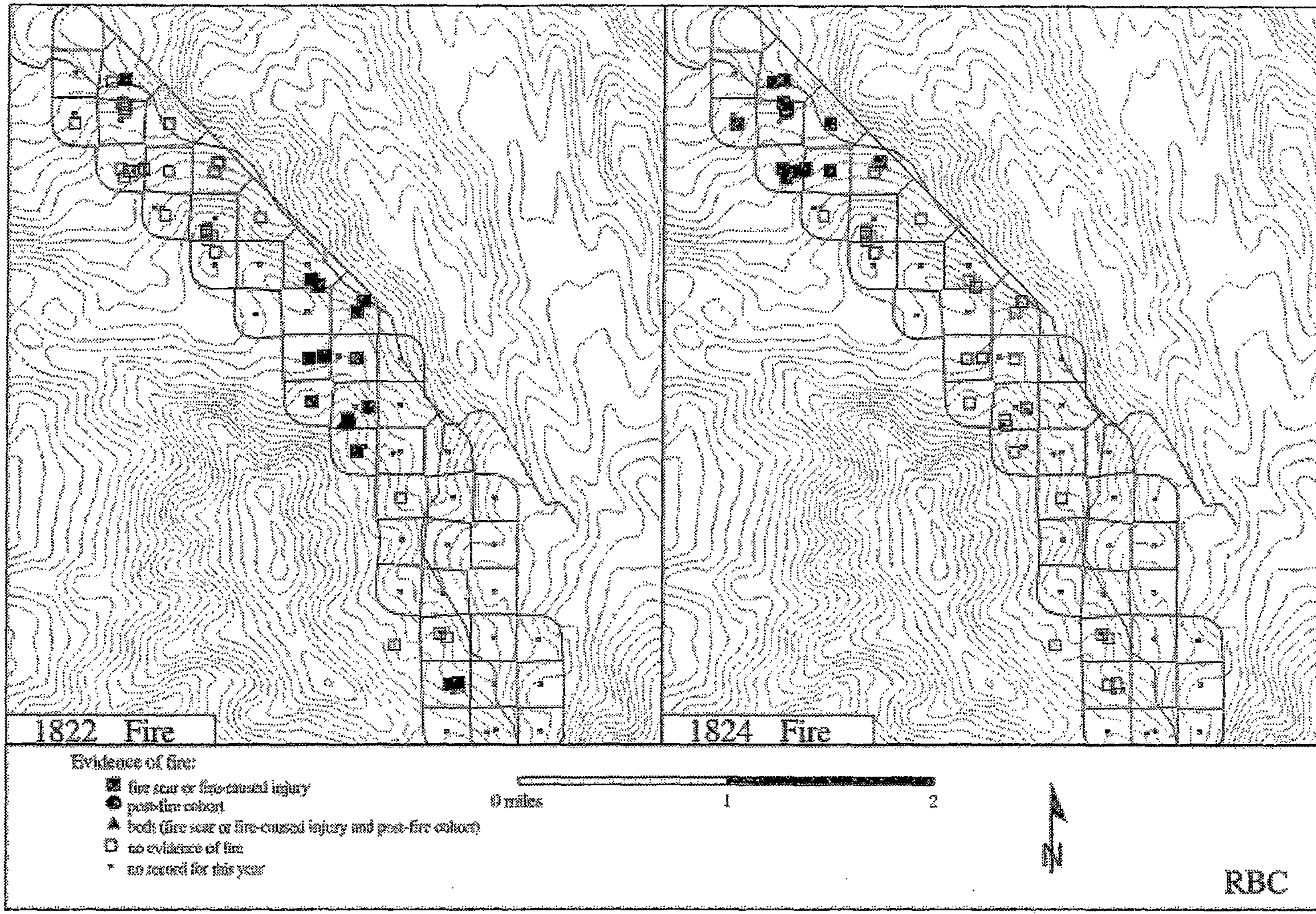

1750 Fire
1751 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC


1762 Fire
1766 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC

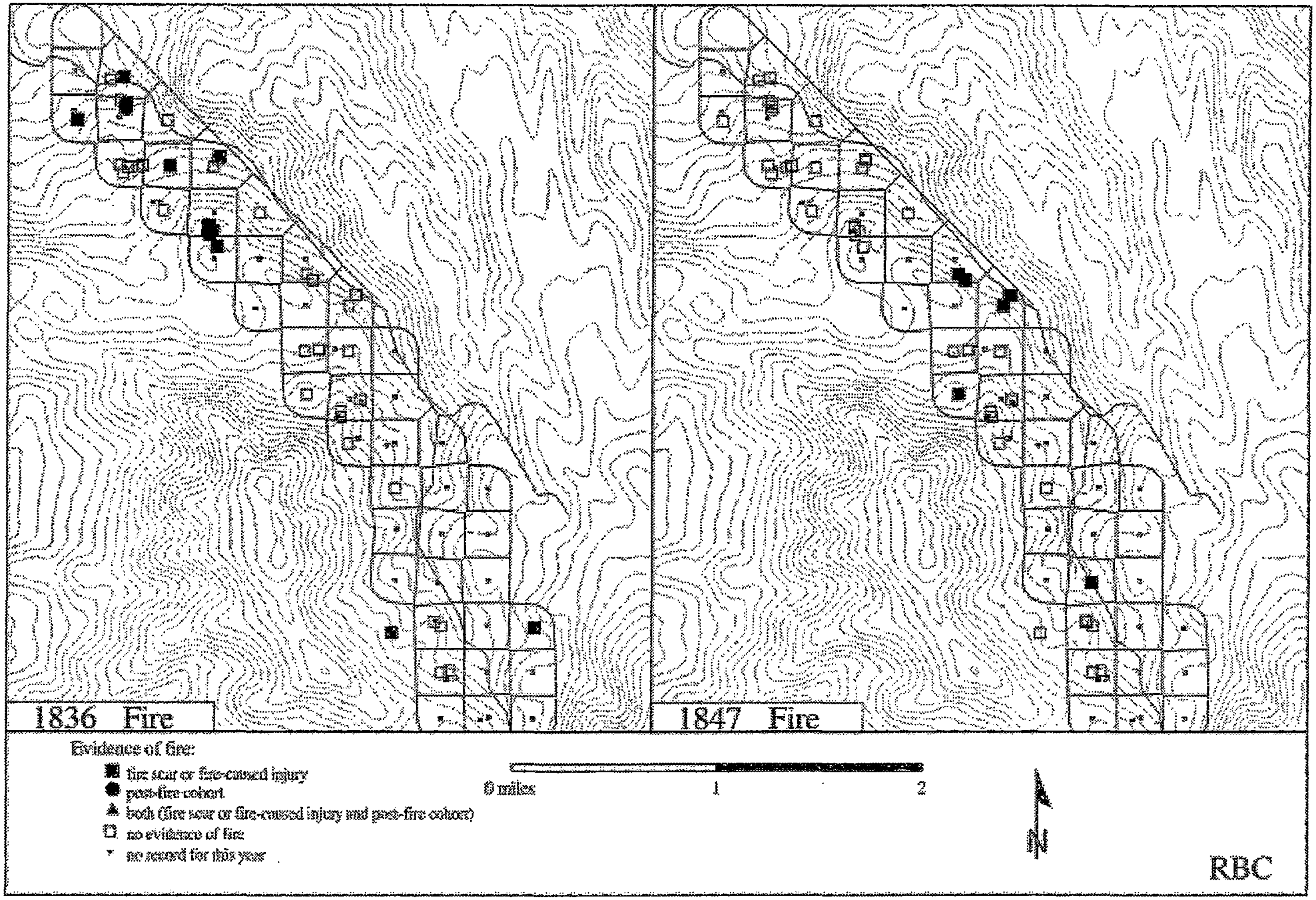

1777 Fire
1780 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC

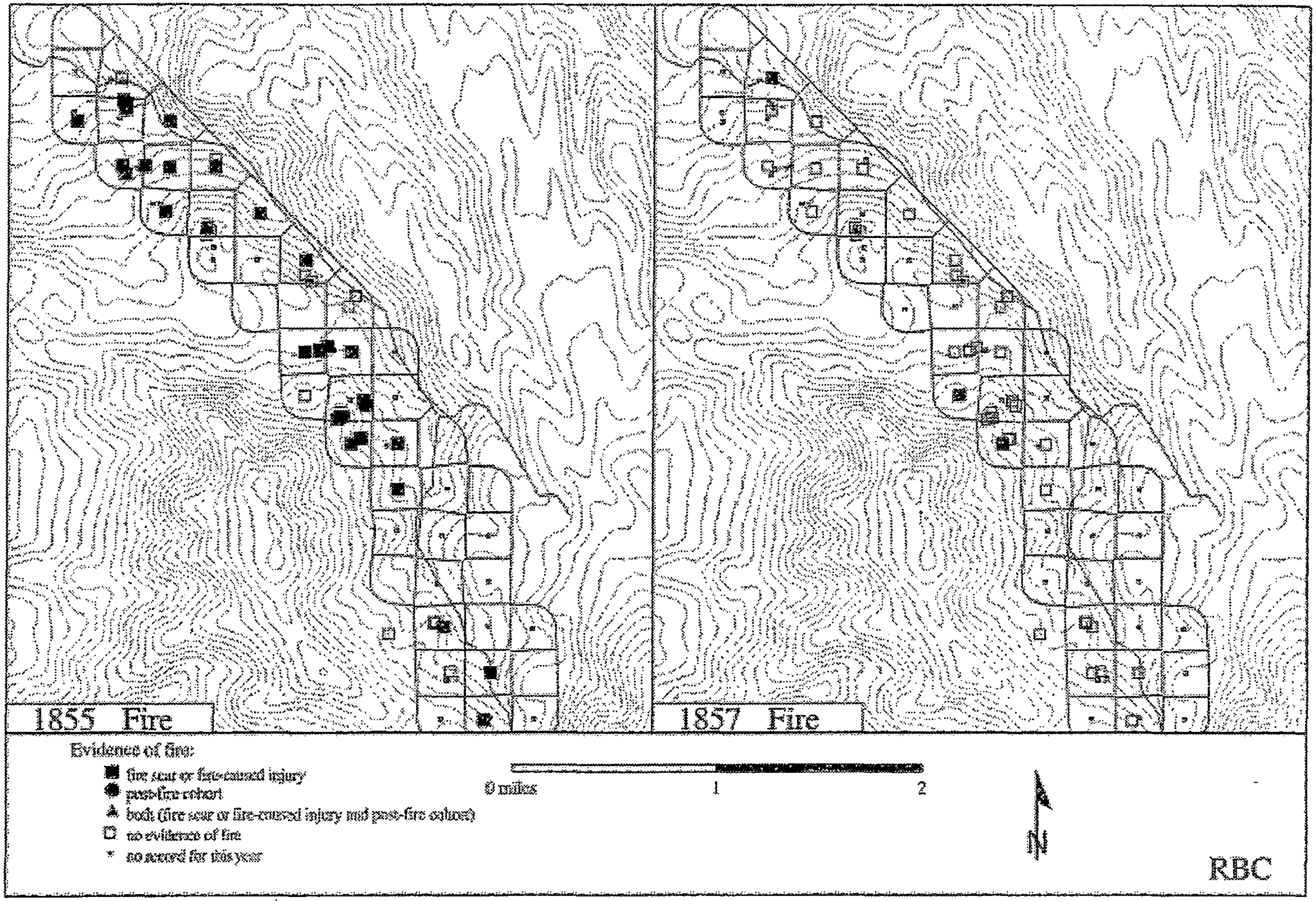

1782 Fire
1789 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC

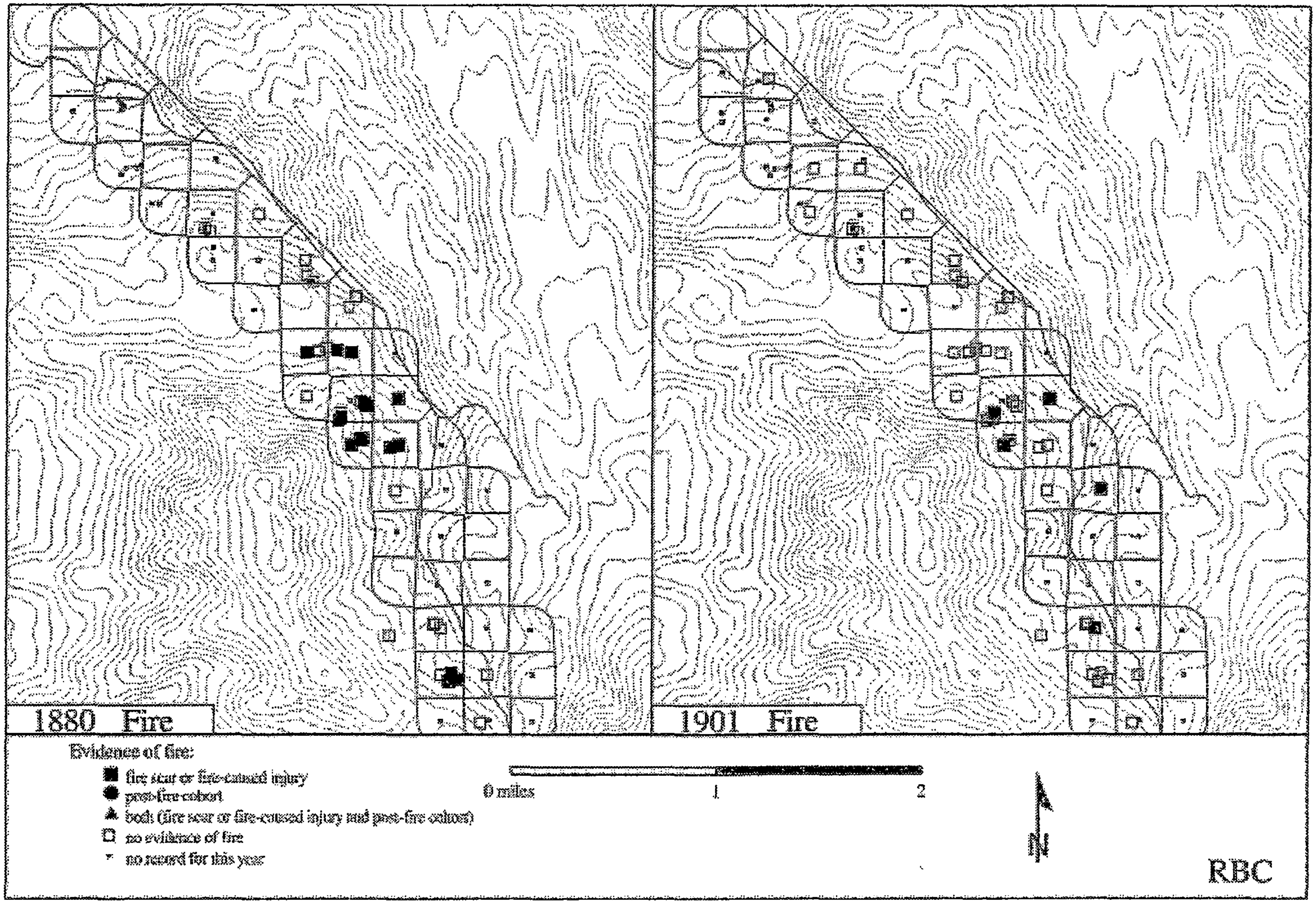

1795 Fire
1806 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC

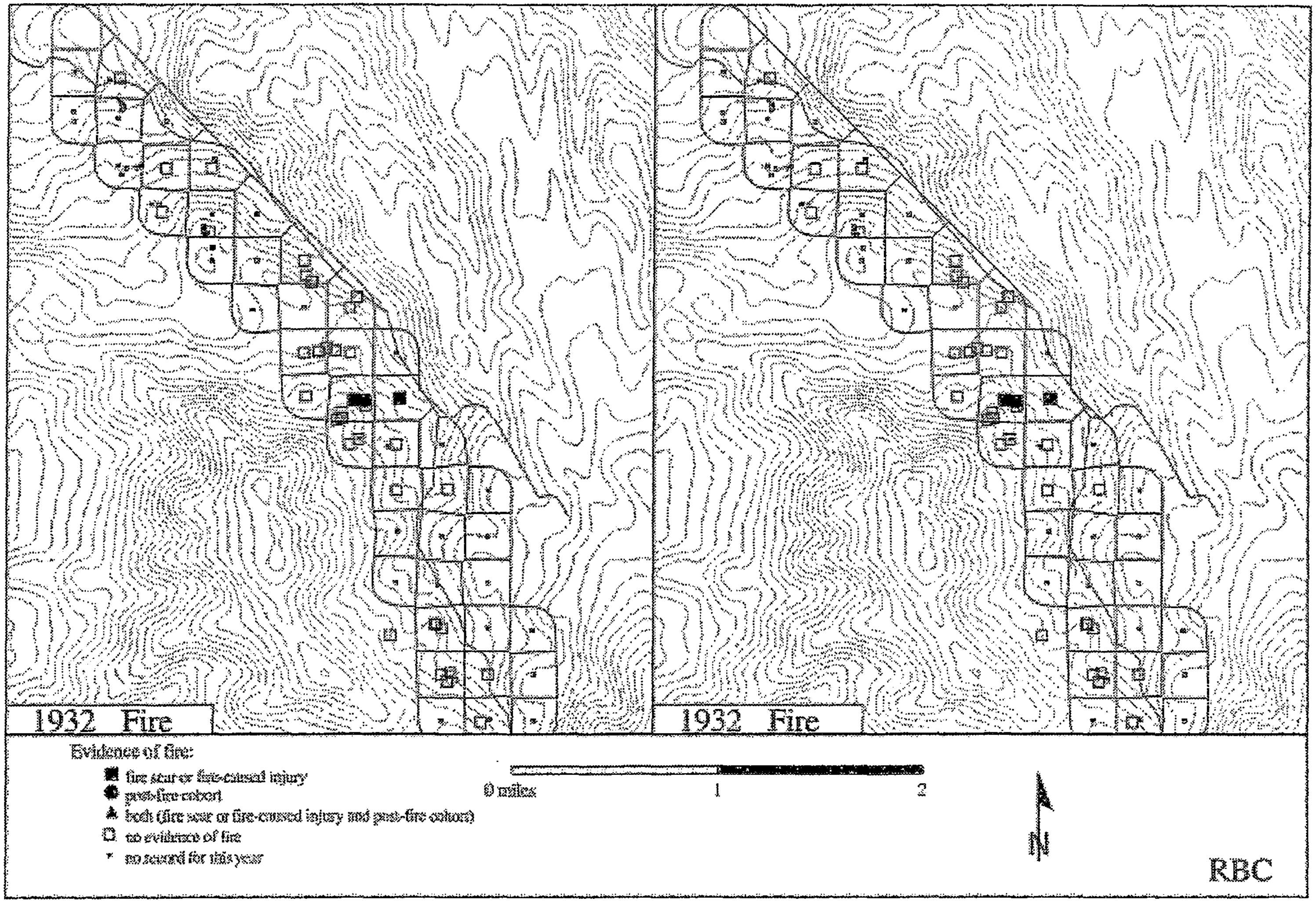


1822 Fire
1824 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC


1836 Fire
1847 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC


1855 Fire
1857 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC


1880 Fire
1901 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC


1932 Fire
1932 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
RBC

TUSHAR MOUNTAINS - FISHLAKE NATIONAL FOREST (INC)

Study Area

We sampled a partial grid of 6 plots over 323 acres near Indian Creek, on the Beaver Ranger District of the Fishlake National Forest in Beaver county, Utah (Figure 78). The plots ranged in elevation from 7757 to 8362 feet, and in slope from 7 to 60%.

Results

Tree recruitment

Our plots included 182 total trees (84% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 158 trees and were able to crossdate most of these (144 trees, or 91% of sampled trees). The trees that occurred on our plots included a range of species (Figure 79). Trees were recruited into the sampled plots between 1479 and 1947, although most trees (80%) were recruited after 1860 (Figure 80).

Average tree density was higher at plots in 2000 than in 1860 for both of the forest types that we assigned to the sampled plots at this site (ponderosa and mixed conifer, Figure 81, Table 2).

Surface fires

We removed fire-scarred sections from a total of 38 trees at INC. We sampled almost half of these (43%) in the 5 of our 6 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were ponderosa pine (89%) or Douglas-fir (8%), but we also sampled a few fire-scarred white fir. Most of the trees we sampled were logs, snags or stumps (58%), with the rest live trees. We were unable to crossdate sections from some of the sampled trees (3%). Those that we did crossdate yielded 157 fire scars, and 30 eroded fire scars or abrupt changes in ring width (1200 to 2002; Figure 82). We were able to assign an intra-ring position to 76% of the fire scars. Most of the scars from the analysis period (1650-1900) were created by fires burning early in the cambial growing season or when the cambium was dormant (83% of assigned scars, Figure 83). Surface fires were historically frequent in the few plots we sampled at this site, but they ceased in the late 1800s (Figure 82).

Figures and tables for INC

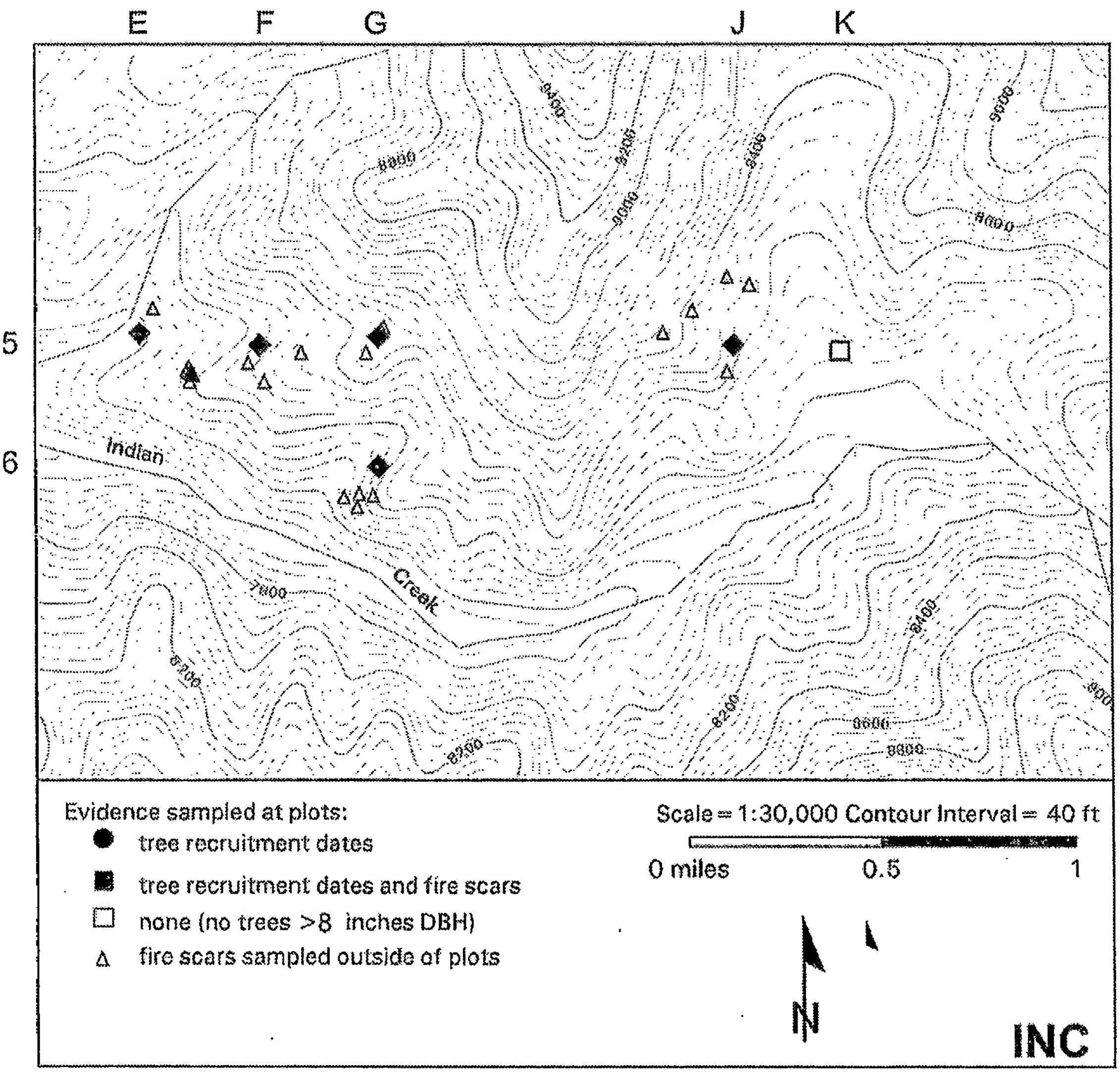


Figure 78. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the northwestern most plot is 5E, the next plot to the east is 5F, etc. Many of the fire-scarred trees (43% of 37 dated trees) were sampled within plots and so are not mapped individually.

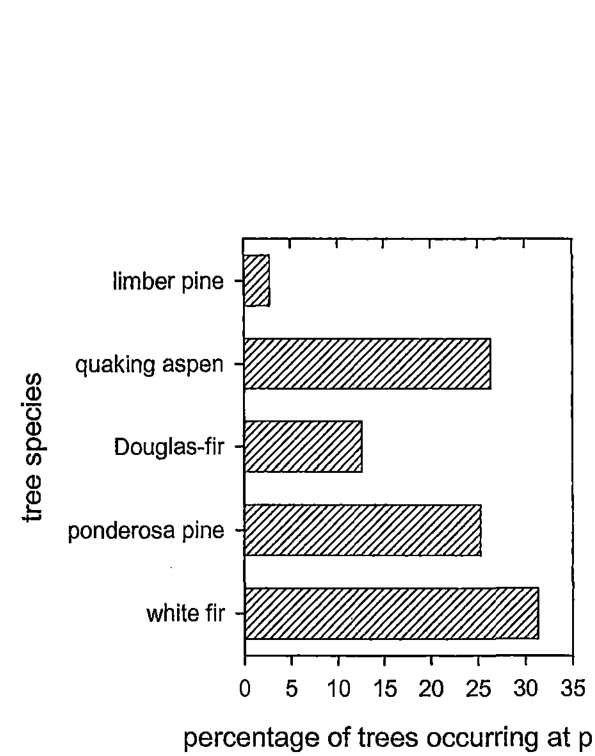


Figure 79. Species distribution of all trees that occurred in plots at INC. In addition, 1 mountain mahogany (*Cercocarpus ledifolius* Nutt. in T. & G.) and 2 Rocky Mountain juniper trees occurred in our plots but are not shown.

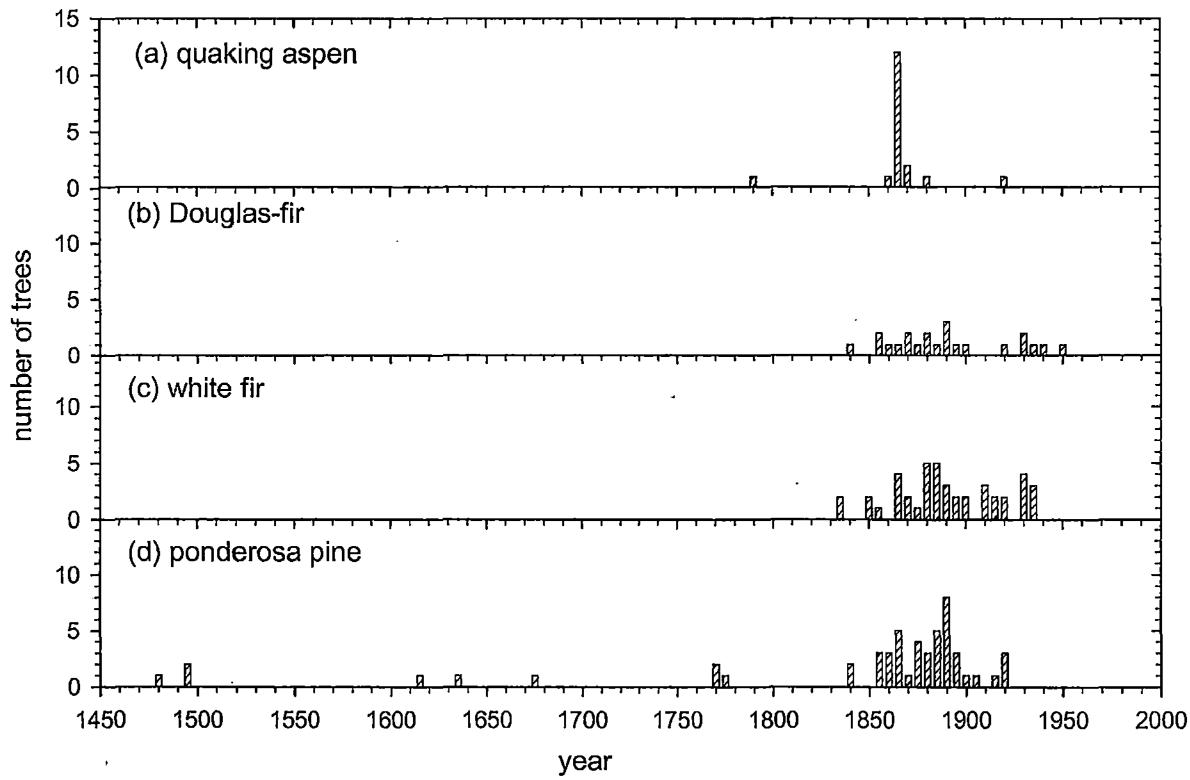


Figure 80. Distribution of tree-recruitment dates by species at INC, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

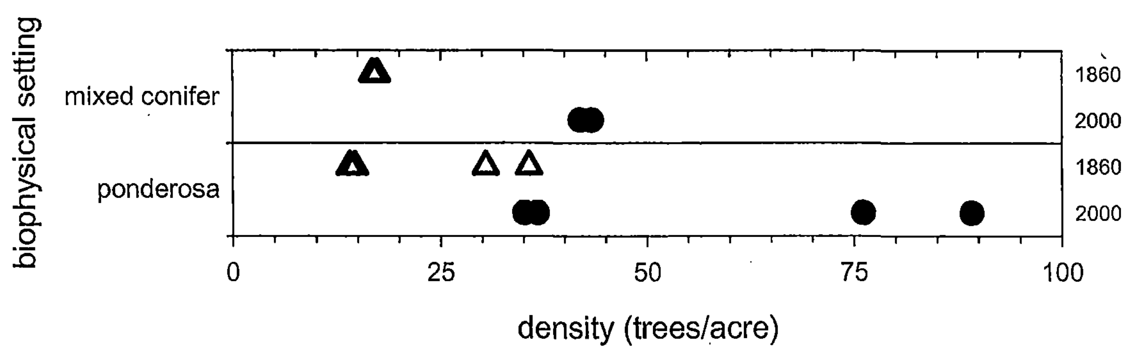


Figure 81. Density of live trees >8 inches DBH at each plot at INC, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

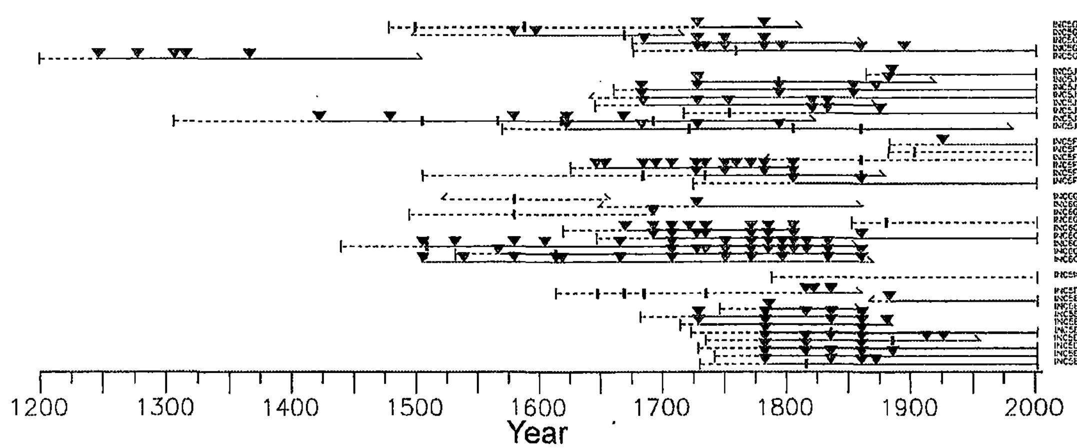


Figure 82. Fire chronologies at INC, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

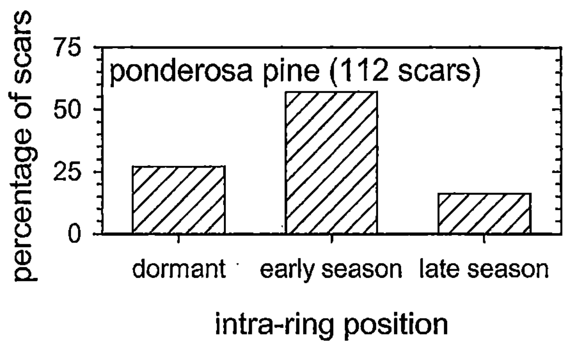
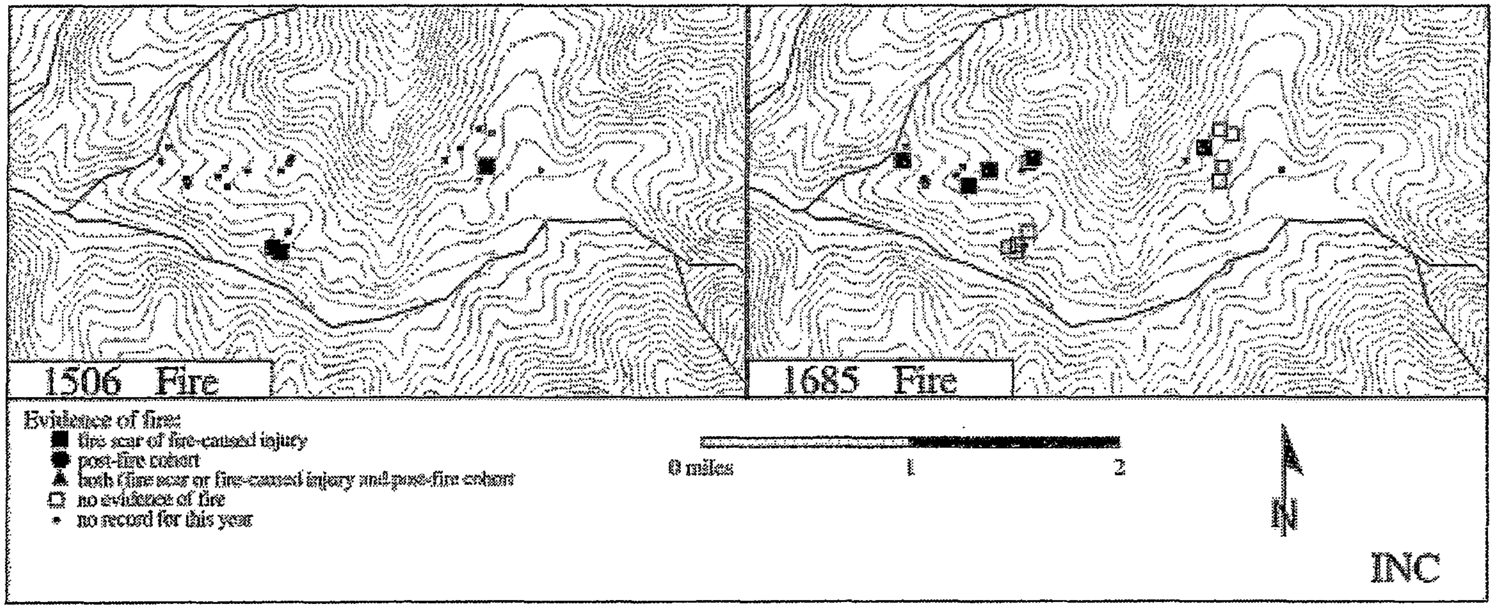
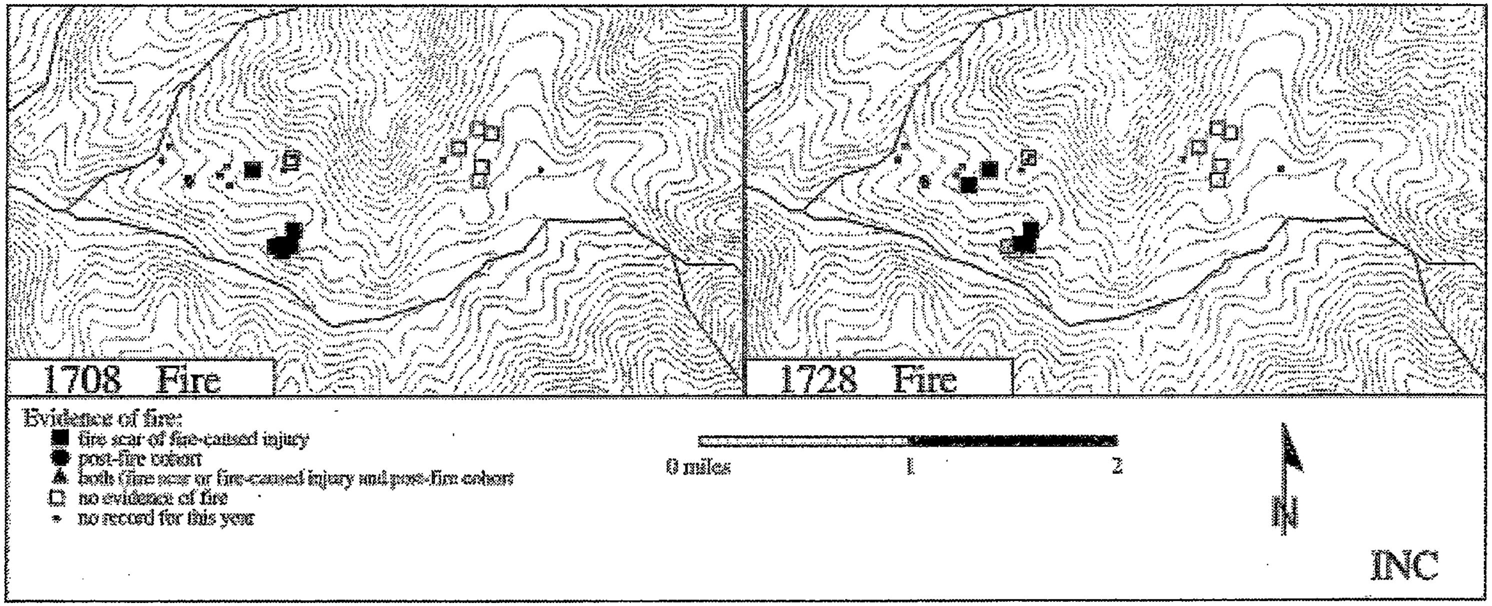


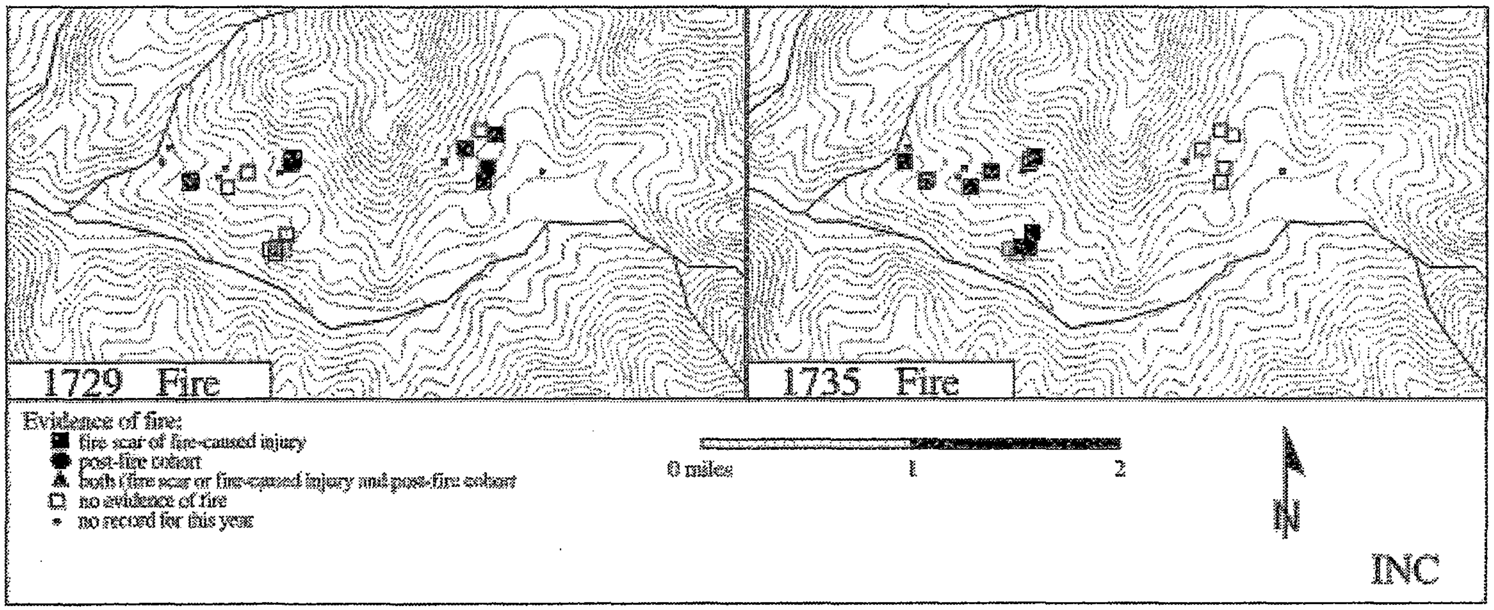
Figure 83. Intra-ring position of fire scars at INC (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only species that comprised >10% of trees are plotted. We also dated scars from some Douglas-fir and white fir, but these species yielded too few scars with an intra-ring position to plot here.

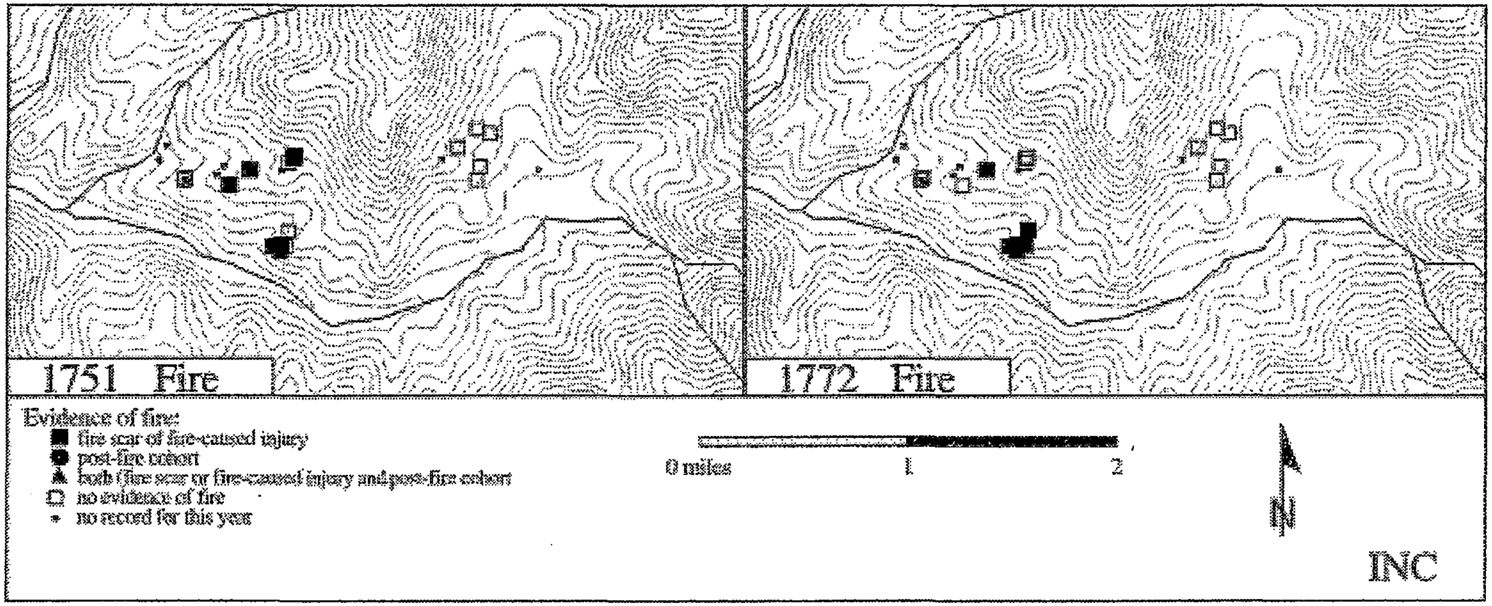
Maps of surface fires at INC

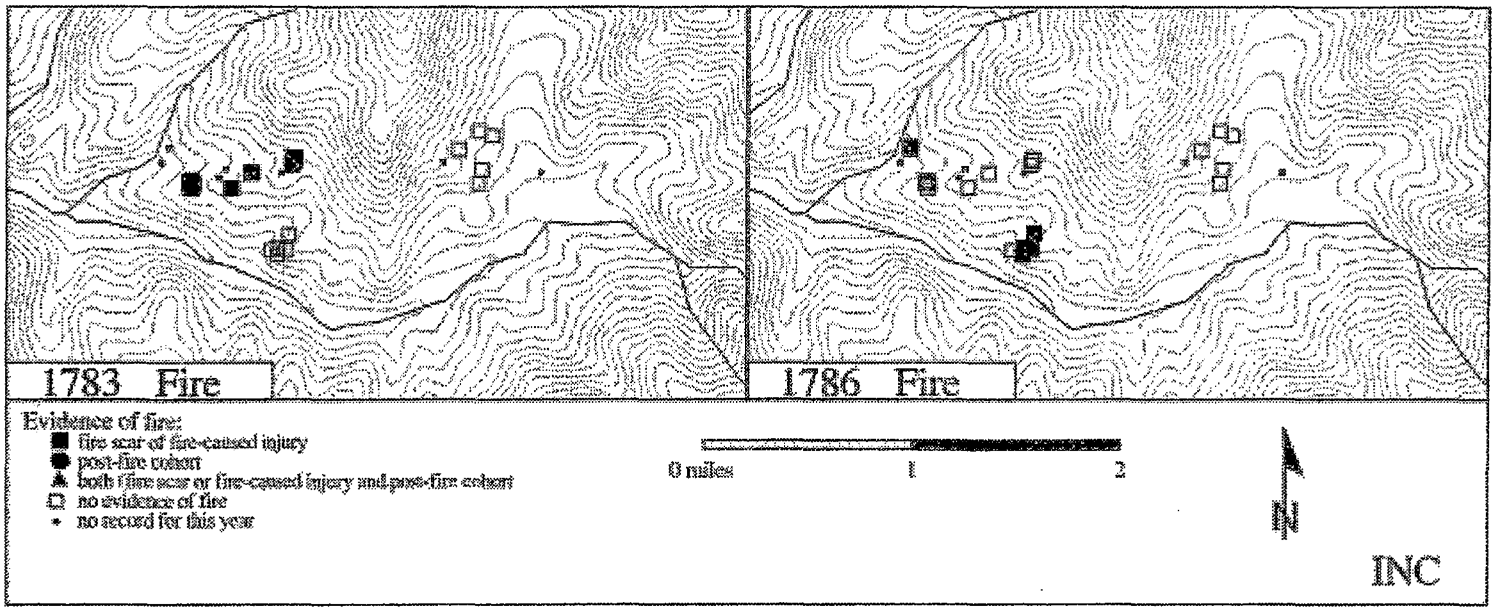
The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.

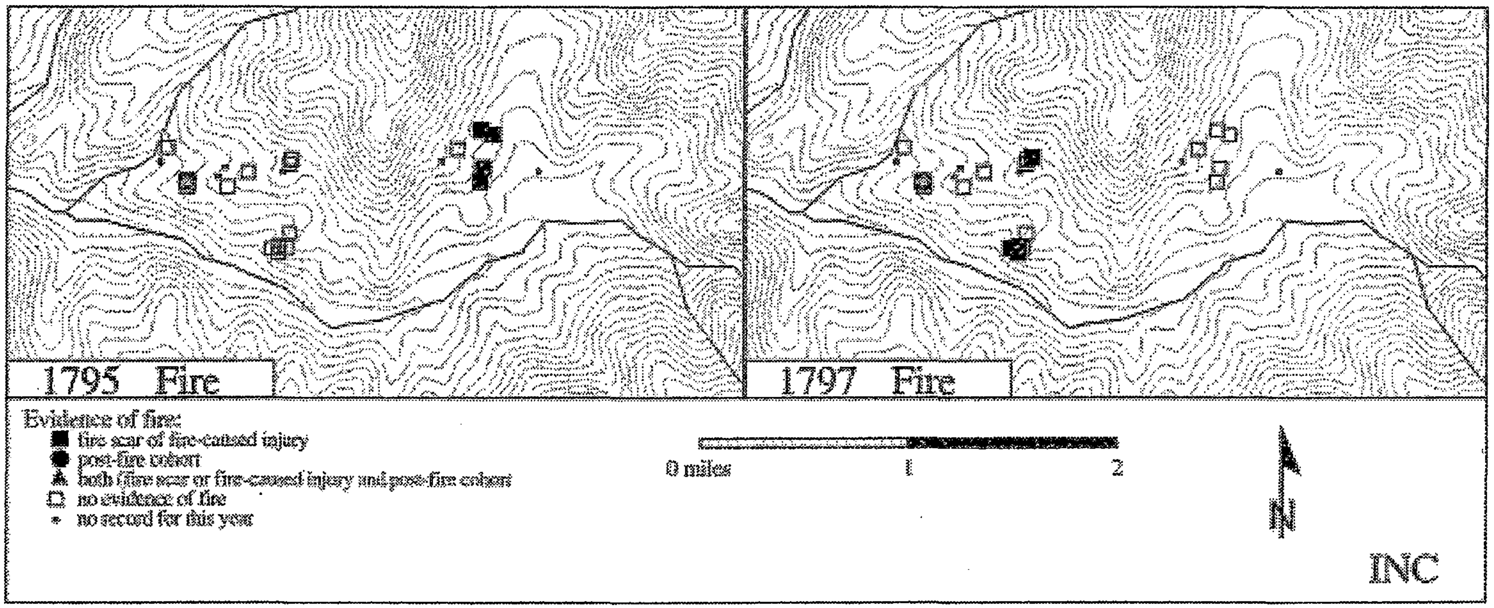

1506 Fire
1685 Fire
Evidence of fire:
fire scar of fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort
no evidence of fire
no record for this year
0 miles
1
2
N
INC

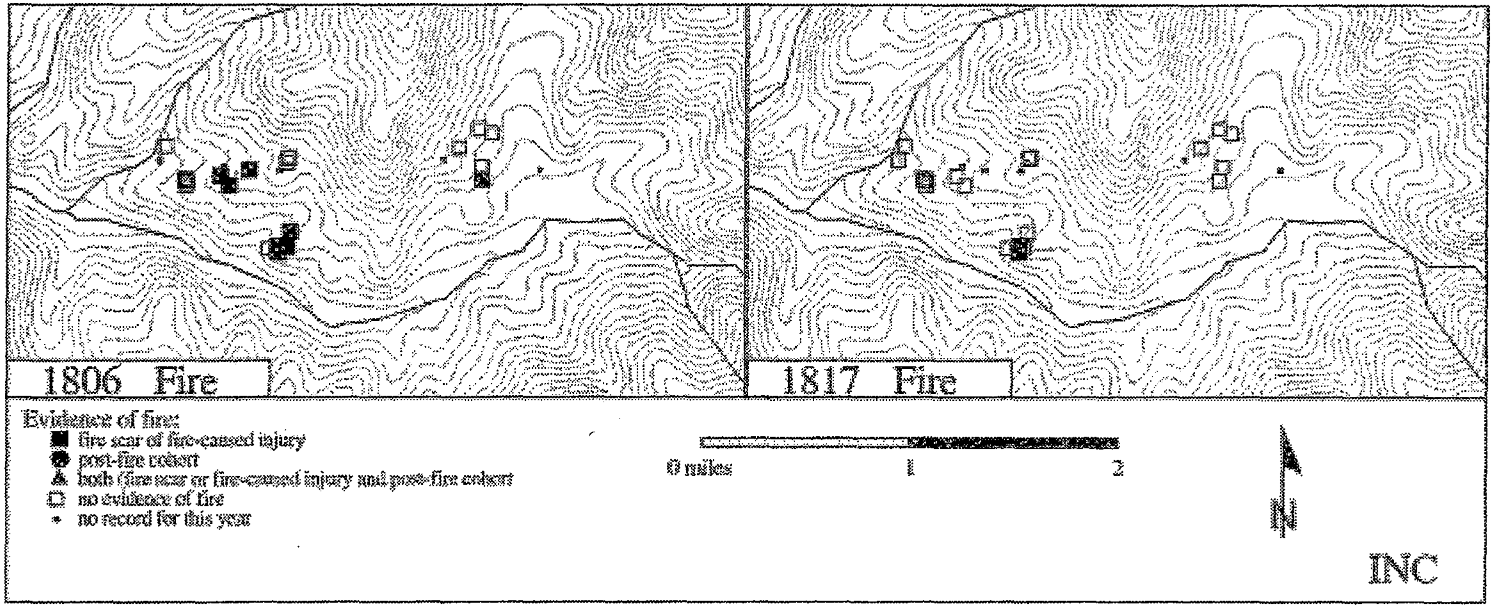

1708 Fire
1728 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort
no evidence of fire
no record for this year
0 miles
1
2
N
INC

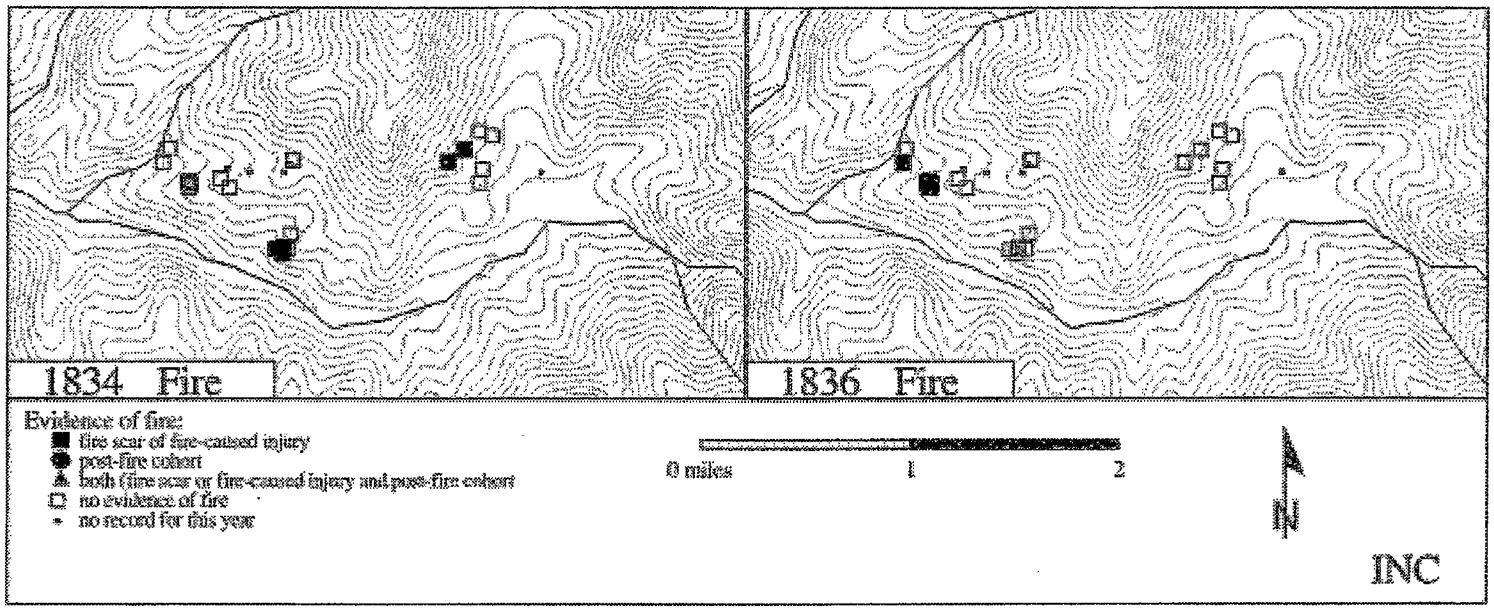

1729 Fire
1735 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort
no evidence of fire
no record for this year
0 miles
1
2
N
INC

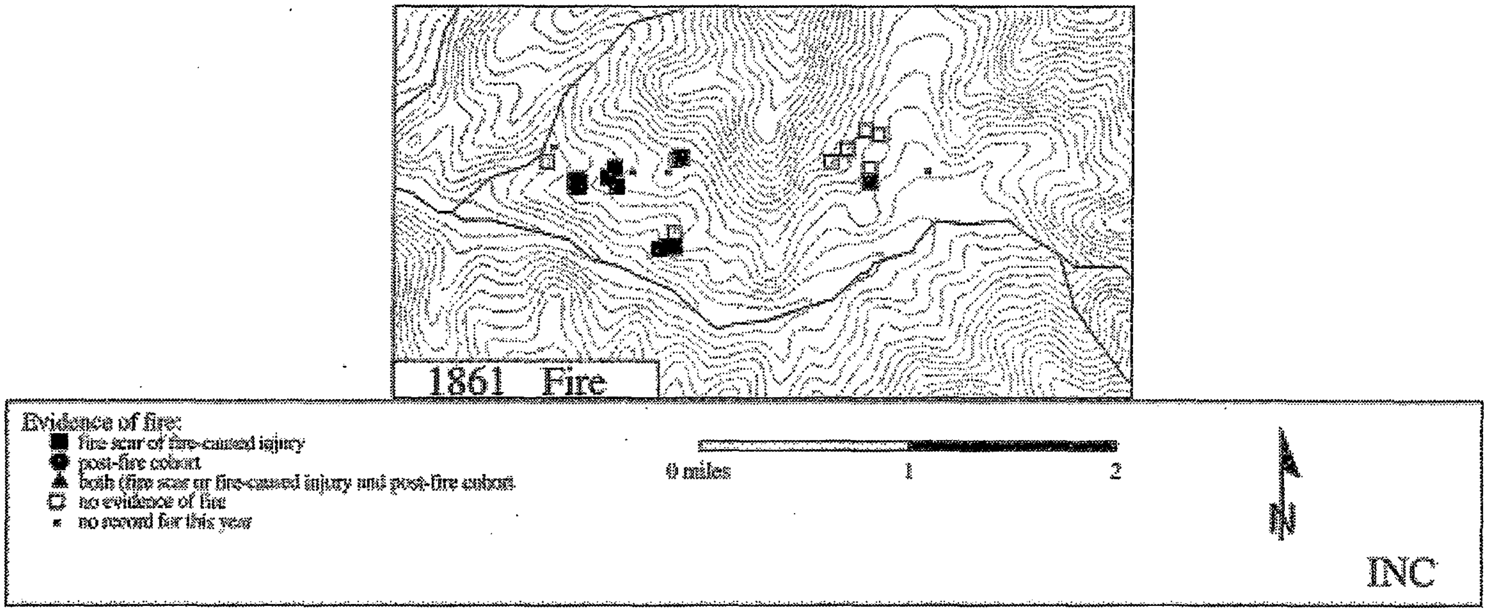

1751 Fire
1772 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort
no evidence of fire
no record for this year
0 miles
1
2
N
INC


1783 Fire
1786 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both fire scar or fire-caused injury and post-fire cohort
no evidence of fire
no record for this year
0 miles
1
2
N
INC


1795 Fire
1797 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort
no evidence of fire
no record for this year
0 miles
1
2
N
INC


1806 Fire
1817 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort
no evidence of fire
no record for this year
0 miles
1
2
N
INC


1834 Fire
1836 Fire
Evidence of fire:
fire scar of fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort
no evidence of fire
no record for this year
0 miles
1
2
N
INC


1861 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
INC

MYTOGE MOUNTAINS - FISHLAKE NATIONAL FOREST (UFR)

Study Area

We sampled a partial grid of 15 plots over 979 acres near Fish and Crater Lakes, on the Loa Ranger District of the Fishlake National Forest in Sevier county, Utah (Figure 84). The plots ranged in elevation from 9184 to 9968 feet, and in slope from 4 to 65%. The plots were sampled on a range of aspects.

Results

Tree recruitment

Our plots included 447 total trees (73% live trees, with the rest logs and snags). Of these, we removed samples from 419 trees and were able to crossdate most of these (299 trees, or 71% of sampled trees). The trees that occurred on our plots included a range of species (Figure 85). Trees were recruited into the sampled plots between 1511 and 1964, although most trees (80%) were recruited after 1776 (Figure 86).

Average tree density was higher at plots in 2000 than in 1860 for all 4 of the forest types that we assigned to the sampled plots at this site (mixed conifer, aspen-mixed conifer, aspen and spruce-fir, Figure 87, Table 2).

Surface fires

We removed fire-scarred sections from a total of 25 trees at UFR. We sampled more than half of these (58%) in the 6 of our 15 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were Douglas-fir (88%) or Engelmann spruce (8%), but we also sampled a few fire-scarred subalpine fir. Most of the trees we sampled were logs or snags (80%), with the rest live trees. We were unable to crossdate sections from some of the sampled trees (24%). Those that we did crossdate yielded 27 fire scars, and 1 eroded fire scars or abrupt changes in ring width (1503 to 2003; Figure 88). We were able to assign an intra-ring position to 44% of the fire scars. Most of the scars from the analysis period (1650-1900) were created by fires burning late in the cambial growing season or when the cambium was dormant (86% of assigned scars, Figure 89).

Figures and tables for UFR

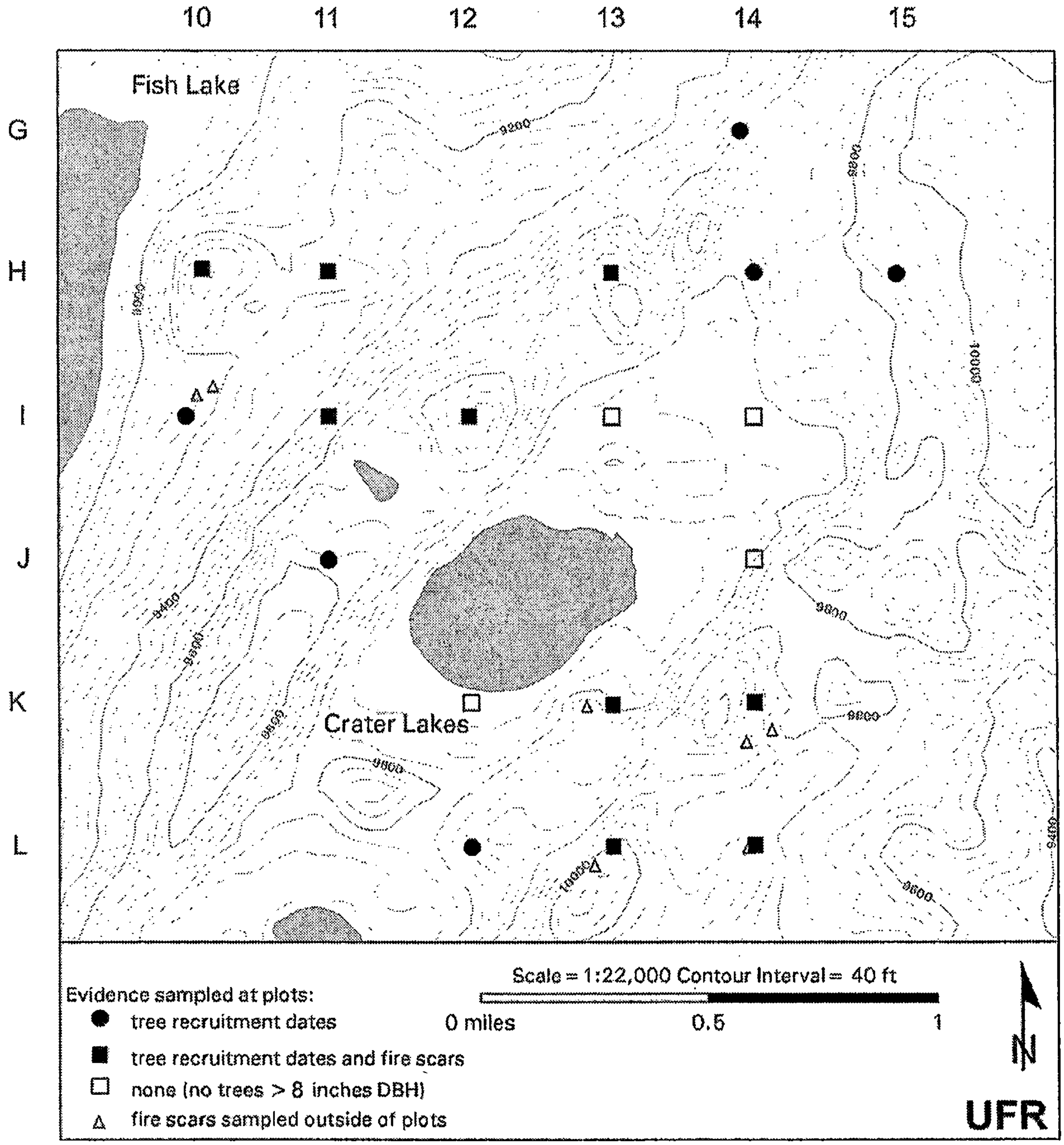


Figure 84. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the northwestern most plot is 10H, the next plot to the east is 11H, etc., but note that the order of the column and row identifiers at this site differs from that at most other sites. Most of the fire-scarred trees (58% of 19 dated trees) were sampled within plots and so are not mapped individually.

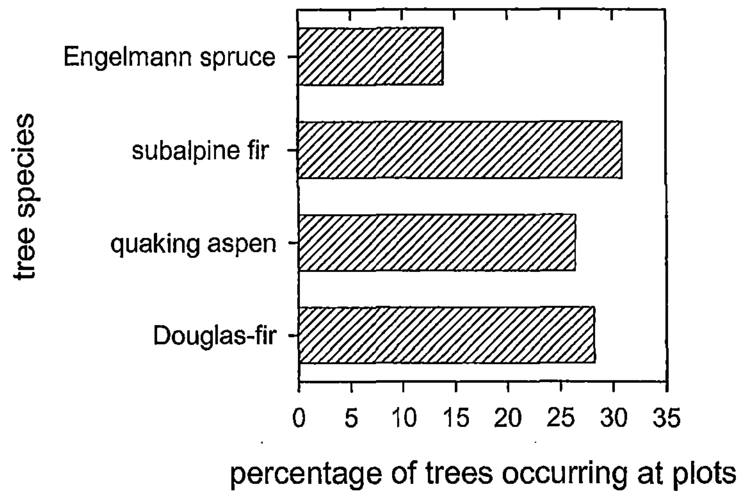


Figure 85. Species distribution of all trees that occurred in plots at UFR. In addition, 1 mountain mahogany tree occurred in our plots but is not shown.

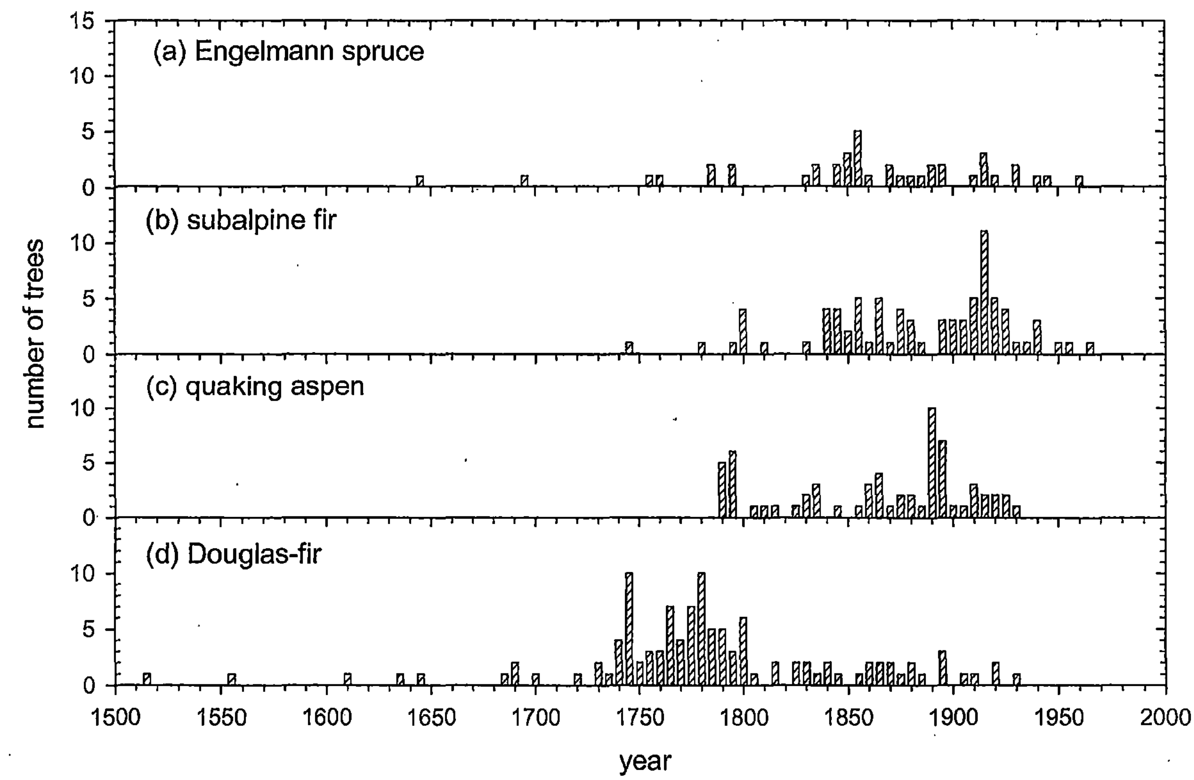


Figure 86. Distribution of tree-recruitment dates by species at UFR, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

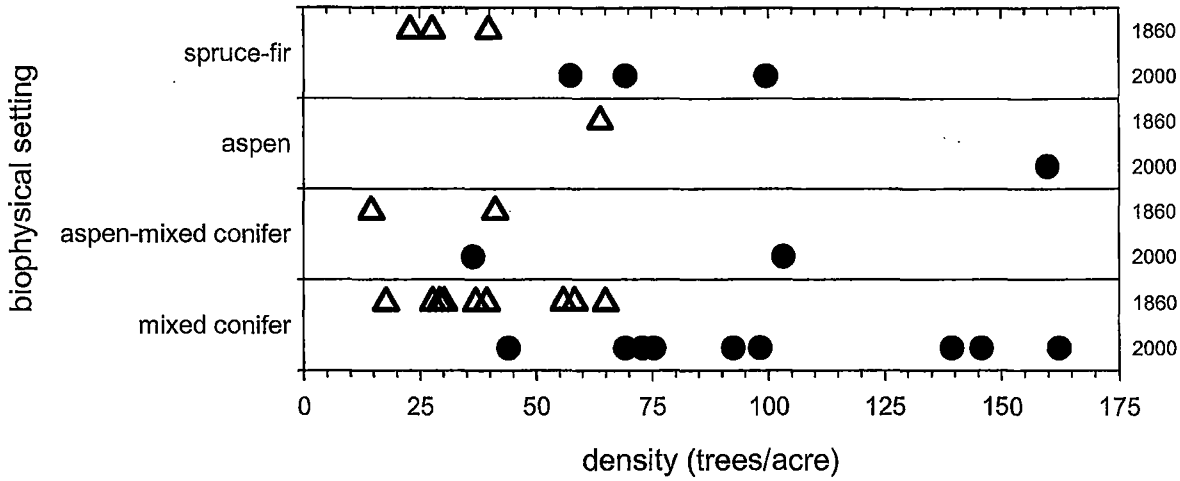


Figure 87. Density of live trees >6 DBH at each plot at UFR, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

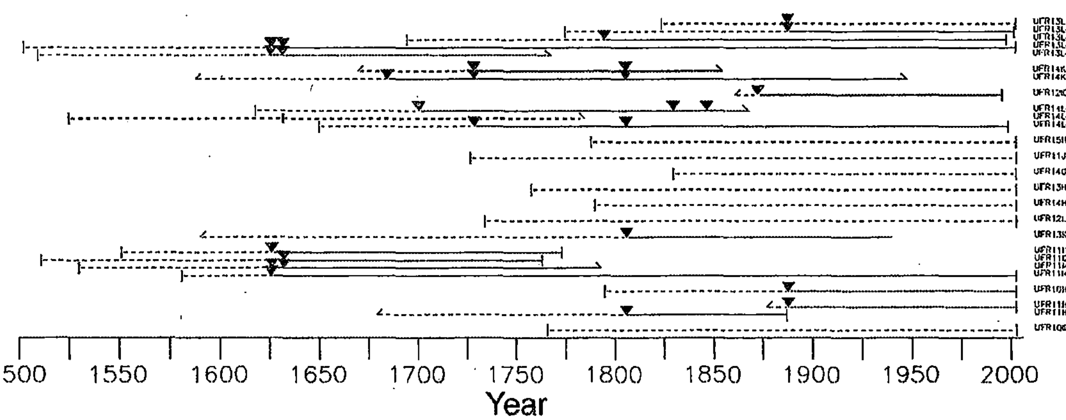


Figure 88. Fire chronologies at UFR, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

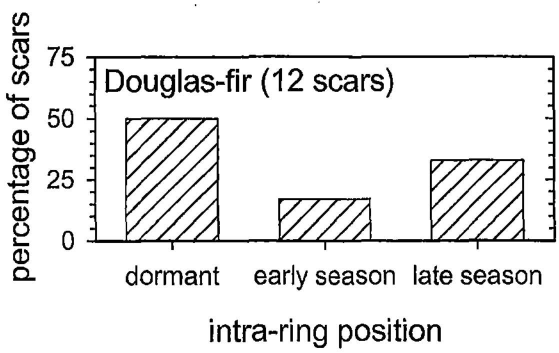
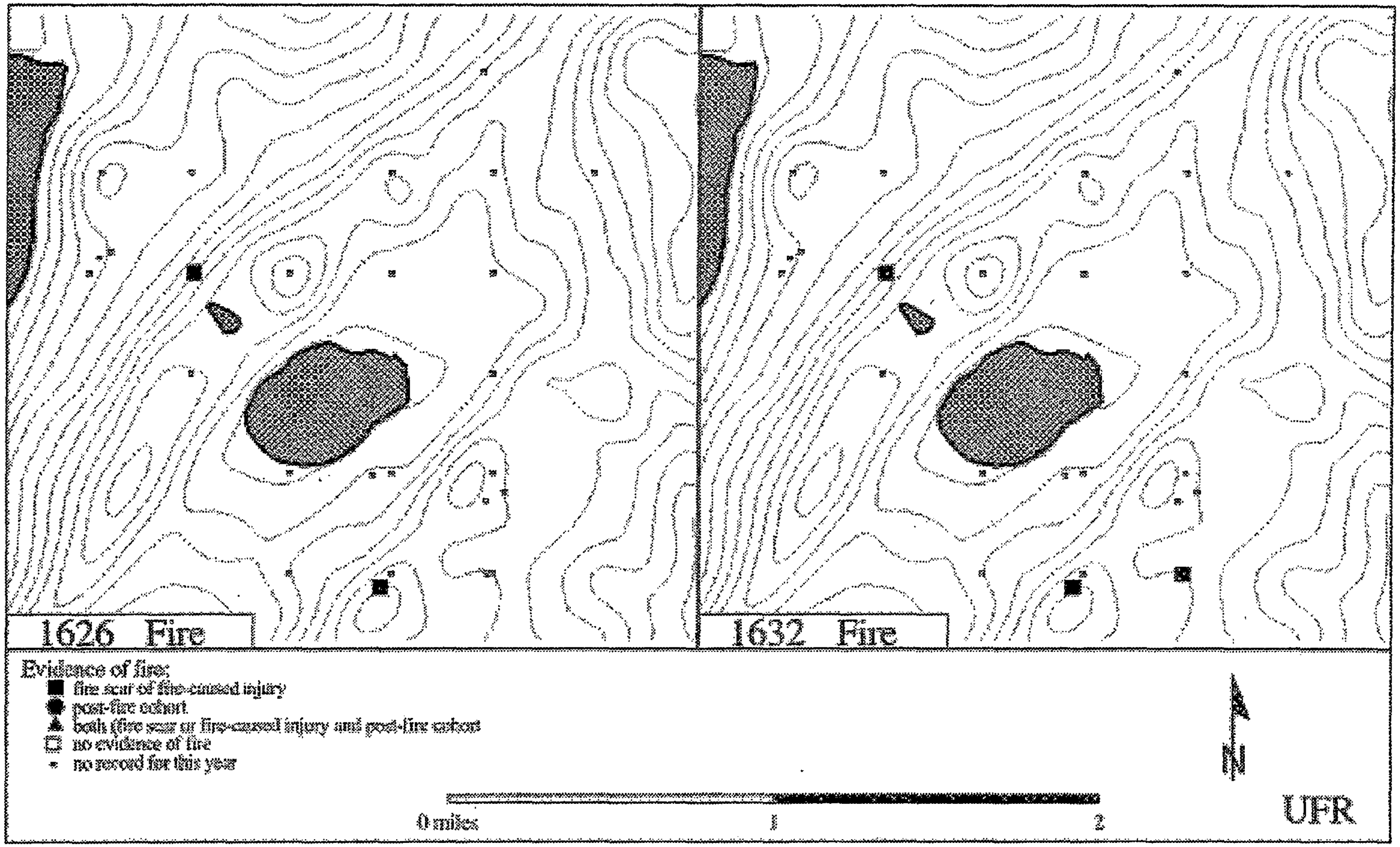
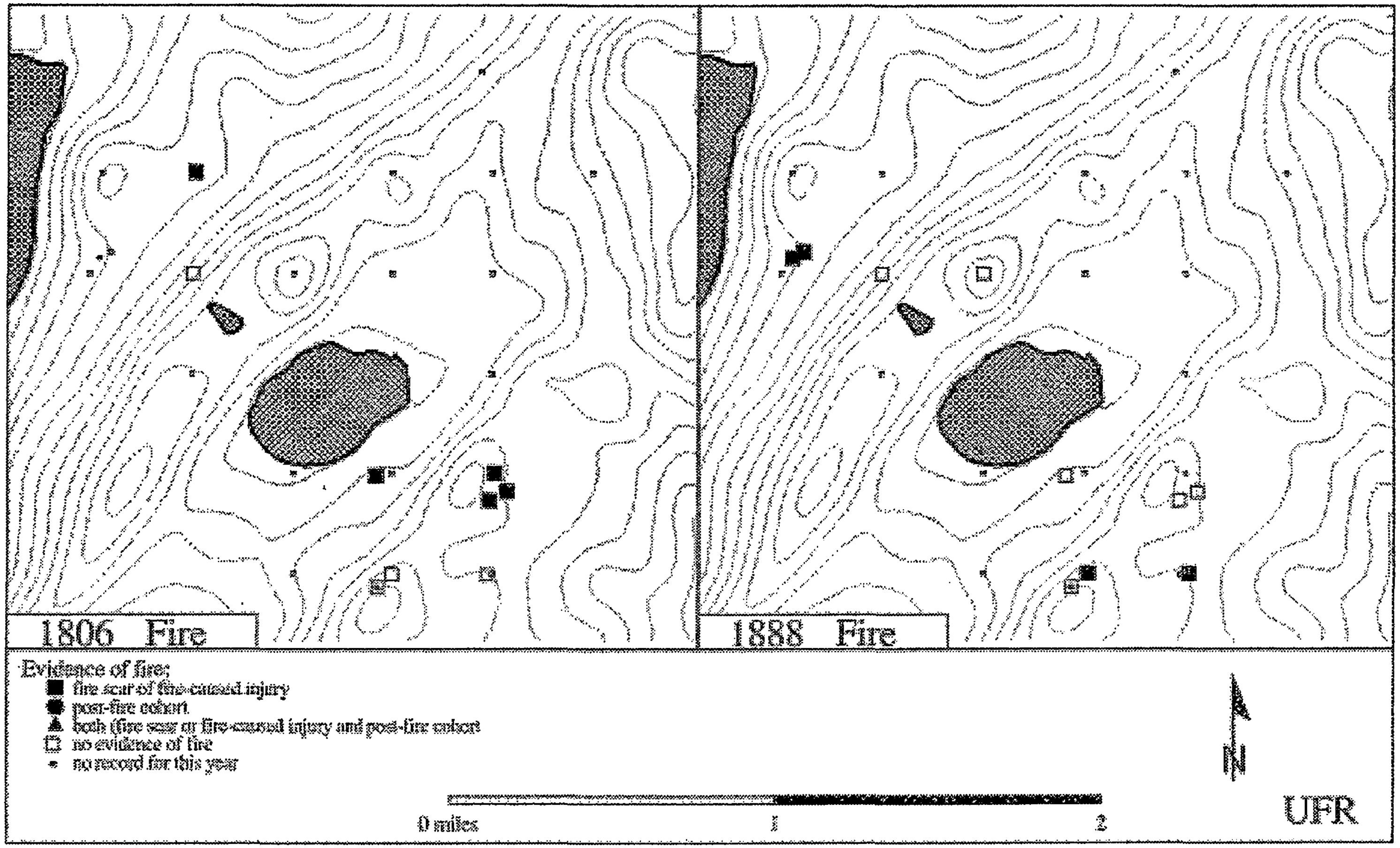


Figure 89. Intra-ring position of fire scars at UFR (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only species that comprised >10% of trees are plotted. We also dated scars from some subalpine fir and Engelmann spruce, but these species yielded too few scars with an intra-ring position to plot here.

Maps of surface fires at UFR

The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.


1626 Fire
1632 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
UFR


1806 Fire
1888 Fire
Evidence of fire;
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort
no evidence of fire
no record for this year
0 miles
1
2
N
UFR

WASATCH PLATEAU - FISHLAKE NATIONAL FOREST (OWP)

Results

Surface fires

We reconstructed a history of surface fires at OWP from 16 fire-scarred ponderosa pine trees. These yielded 95 fire scars, and no eroded fire scars or abrupt changes in ring width (1490 to 1996; Figure 90). We were able to assign an intra-ring position to 65% of these fire scars. Most of the scars from the analysis period (1650-1900) were created by fires burning late in the cambial growing season or when the cambium was dormant (81% of assigned scars, Figure 91). Historically, surface fires were frequent at OWP, with fires occurring every 12 years on average (Figure 92). Surface fires ceased around 1900 at this site (Figure 90).

Figures and tables for OWP

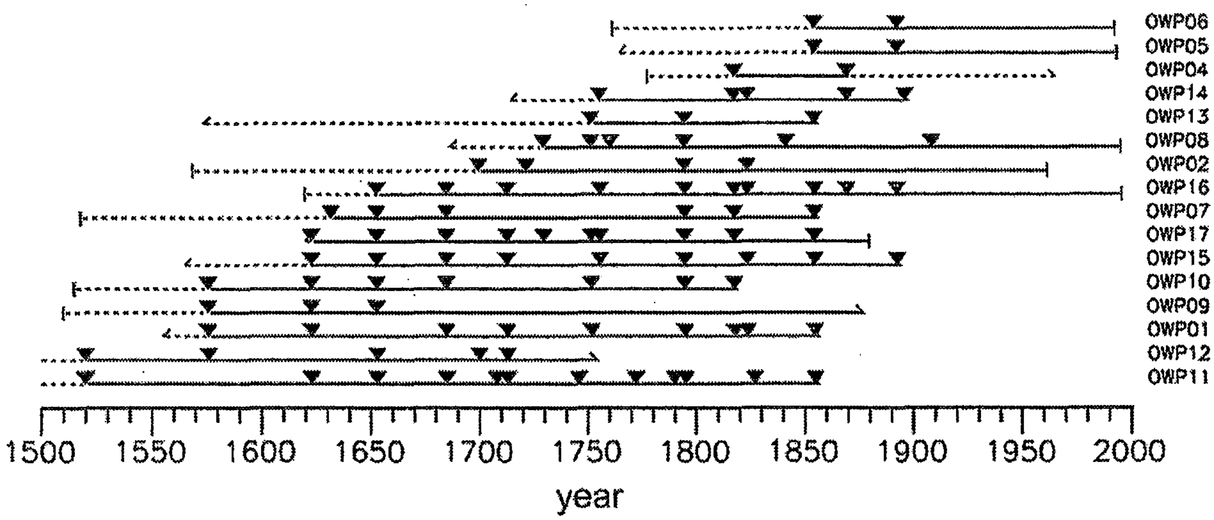


Figure 90. Fire chronology at OWP (Grissino-Mayer 1995). Horizontal lines show the fire record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inner and outer dates are the dates of the earliest or latest rings sampled from trees where pith or bark was not sampled.

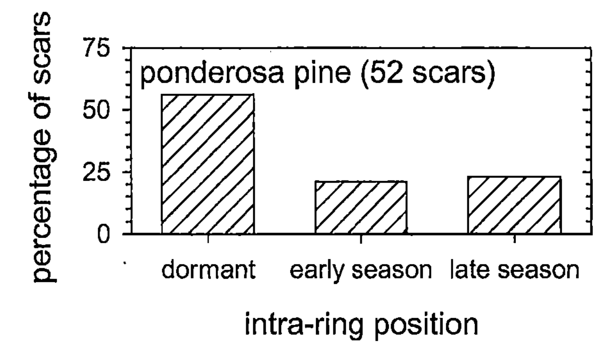


Figure 91. Intra-ring position of fire scars at OWP (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only ponderosa pine trees were sampled at this site.

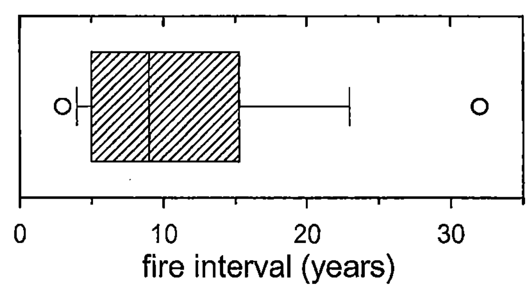


Figure 92. Distribution of fire intervals at OWP during the analysis period (1650-1900), composited from trees sampled over 49 acres (21 fire intervals total).

MONROE MOUNTAIN - FISHLAKE NATIONAL FOREST (MON)

Results

Surface fires

We reconstructed a history of surface fires at MON from 12 fire-scarred trees. These yielded 37 fire scars, and 4 eroded fire scars or abrupt changes in ring width (1515 to 1994; Figure 93). We were able to assign an intra-ring position to 92% of these fire scars. About half the scars from the analysis period (1650-1900) were created by fires burning late in the cambial growing season or when the cambium was dormant (52% of assigned scars, Figure 94).

Figures and tables for MON

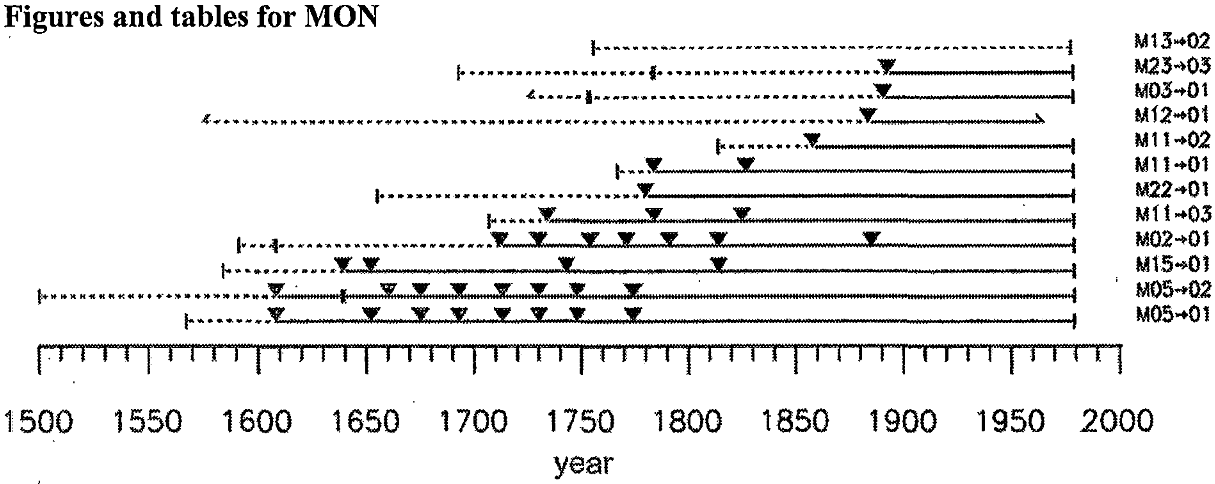


Figure 93. Fire chronology at MON (Grissino-Mayer 1995). Horizontal lines show the fire record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inner and outer dates are the dates of the earliest or latest rings sampled from trees where pith or bark was not sampled.

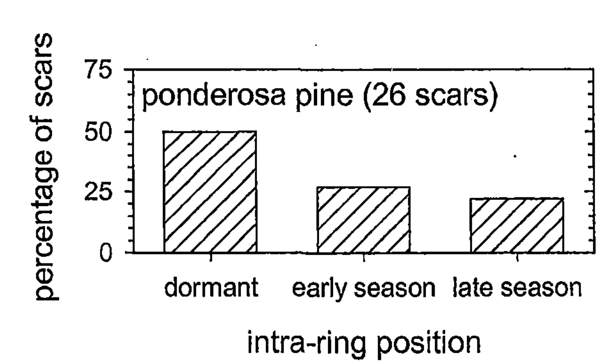


Figure 94. Intra-ring position of fire scars at MON (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Too few scars were sampled on other species for us to determine their distribution by intra-ring position.

PAUNSAGUNT PLATEAU - DIXIE NATIONAL FOREST (PSG)

Study Area

We sampled a grid of 29 plots over 1787 acres in Meadow Canyon, on the Powell Ranger District of the Dixie National Forest in Kane county, Utah (Figure 95). The plots ranged in elevation from 7576 to 8978, and in slope from 4 to 75%. The plots were sampled on a range of aspects, although most plots were on north or east aspects (70%, Figure 96). The topography of the plots we sampled was generally similar to that of the sampling area at this site.

Results

Tree recruitment

Our plots included 844 total trees (87% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 745 trees and were able to crossdate most of these (667 trees, or 90% of sampled trees). The trees that occurred on our plots included a range of species (Figure 97). Trees were recruited into the sampled plots between 1418 and 1974, although most trees (80%) were recruited after 1851 (Figure 98).

Average tree density was higher at plots in 2000 than in 1860 for all 6 of the forest types that we assigned to the sampled plots at this site (shrubland, pinyon-juniper, ponderosa, mixed conifer, aspen and spruce-fir, Figure 99, Table 2).

Surface fires

We removed fire-scarred sections from a total of 85 trees at PSG. We sampled almost half of these (44%) in the 14 of our 29 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were ponderosa pine (77%) or Douglas-fir (11%), but we also sampled a few fire-scarred white fir, Engelmann spruce and limber pine. Most of the trees we sampled were logs, snags or stumps (70%), with the rest live trees. We were unable to crossdate sections from some of the sampled trees (39%). Those that we did crossdate yielded 148 fire scars, and 12 eroded fire scars or abrupt changes in ring width (1524 to 2004; Figure 100). We were able to assign an intra-ring position to 80% of the fire scars. Most of the scars from the analysis period (1650-1900) were created by fires burning early in the cambial growing season or when the cambium was dormant (77% of assigned scars, Figure 101).

The number of surface fires during the analysis period (1650-1900) did not vary substantially with elevation or forest type at PSG (Figure 102). Surface fires ceased in the mid 1800s at this site (Figure 100).

Figures and tables for PSG

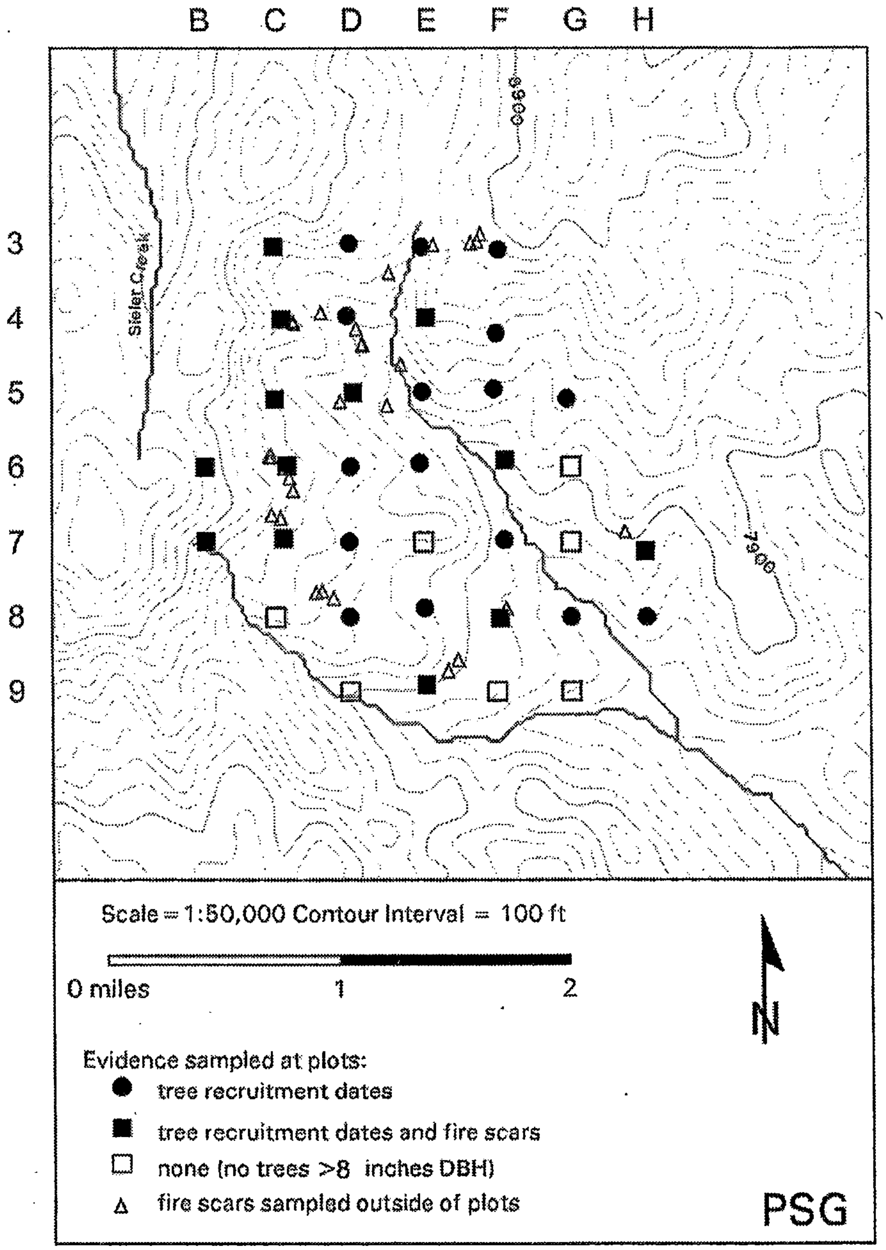


Figure 95. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the northwestern most plot is 3C, the next plot to the east is 3D, etc. Many of the fire-scarred trees (44% of 52 dated trees) were sampled within plots and so are not mapped individually.

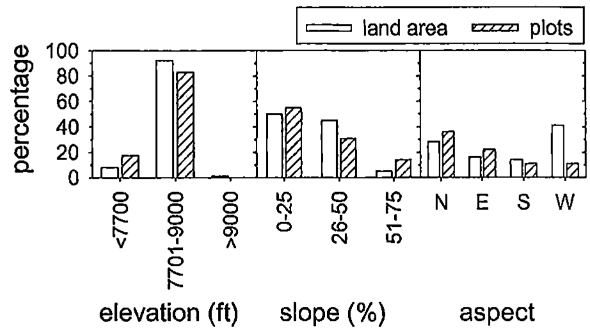


Figure 96. Distribution of topography for sampled plots and for land area at PSG. Aspect classes are 90° wide, beginning with 46° for east (E). Land area was derived from a digital elevation model.

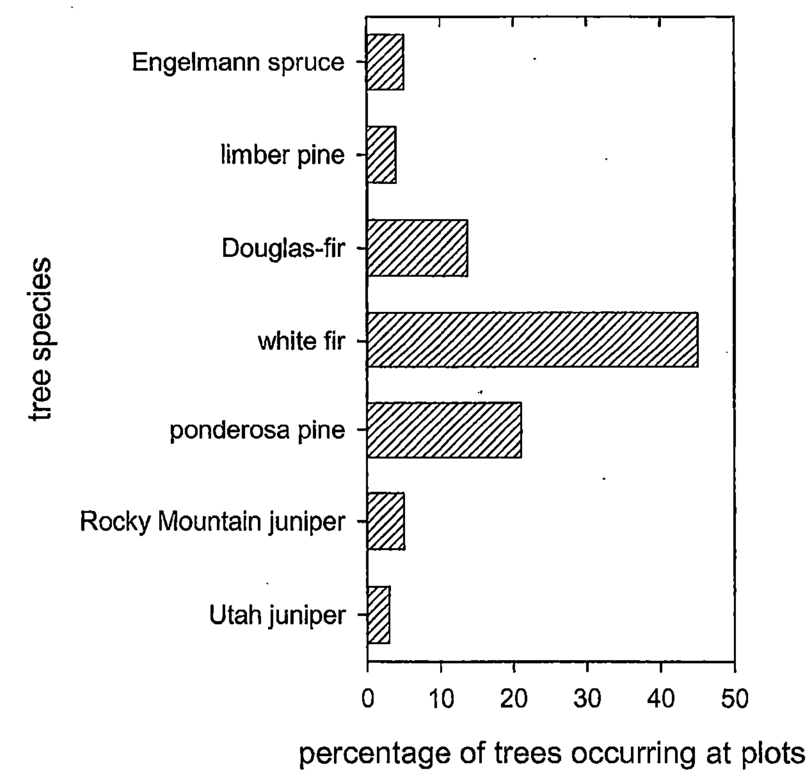


Figure 97. Species distribution of all trees that occurred in plots at PSG. In addition, 16 quaking aspen and 9 two-needle pinyon trees occurred in our plots but are not shown.

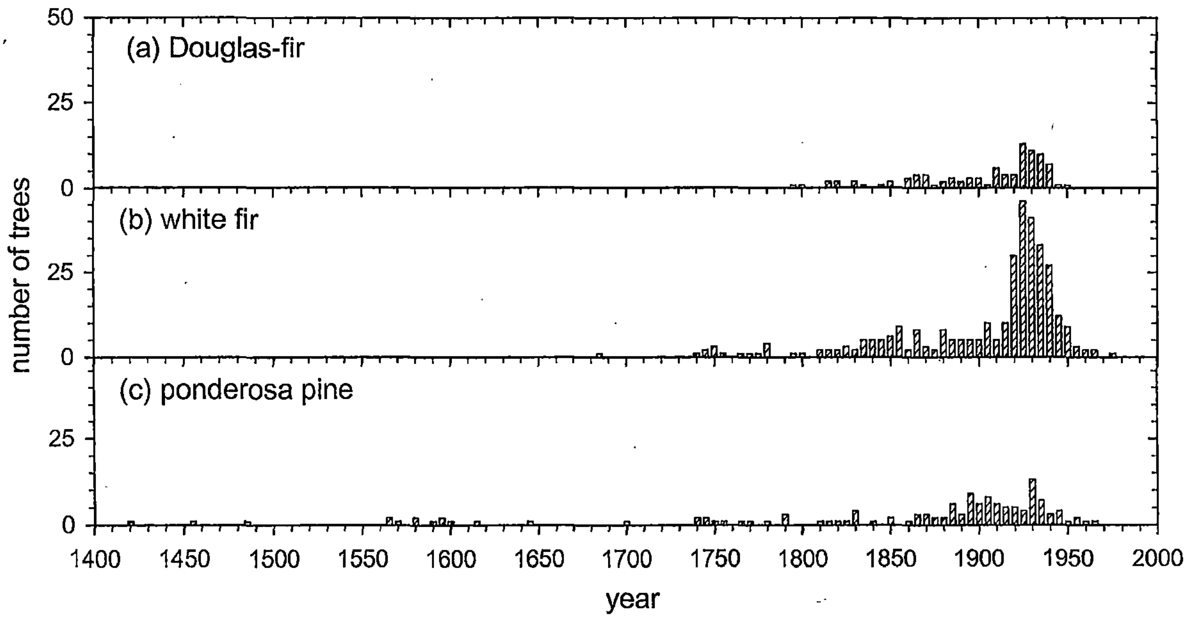


Figure 98. Distribution of tree-recruitment dates by species at PSG, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

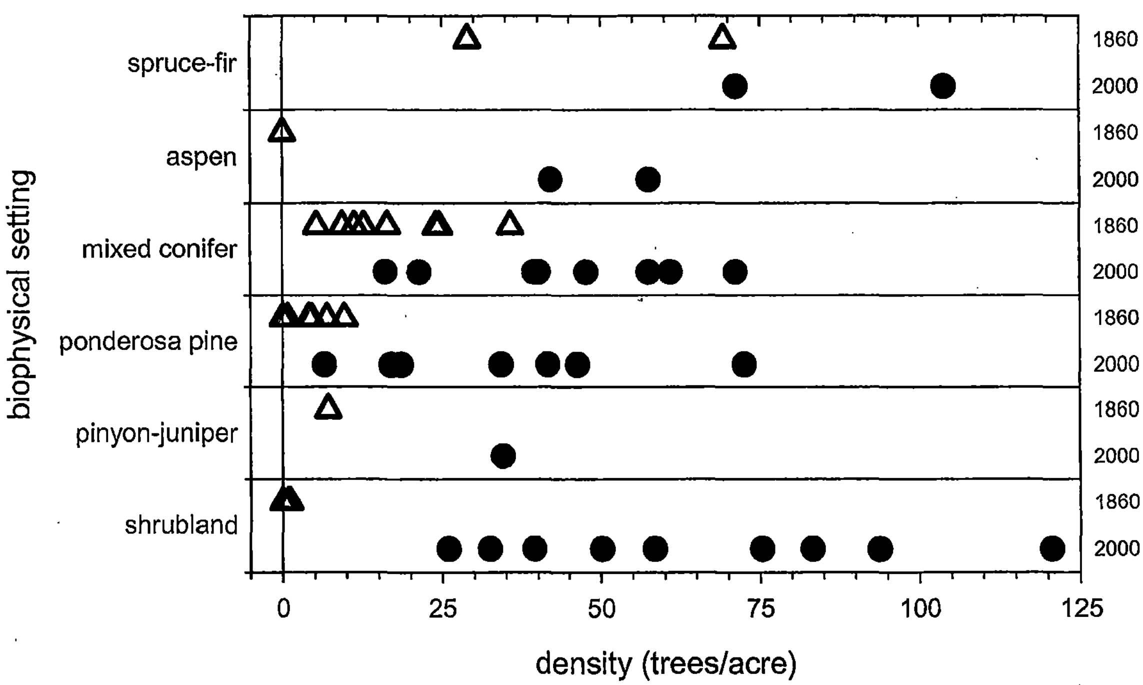


Figure 99. Density of live trees >8 inches DBH at each plot at PSG, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

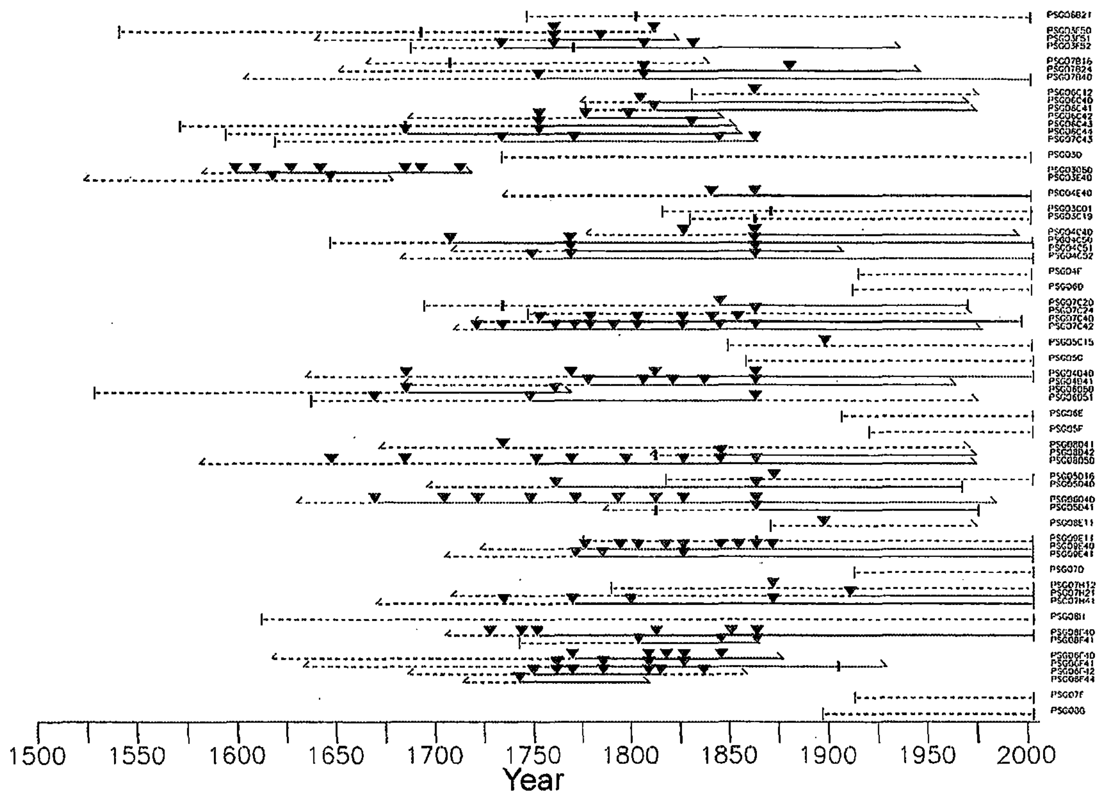


Figure 100. Fire chronologies at PSG, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

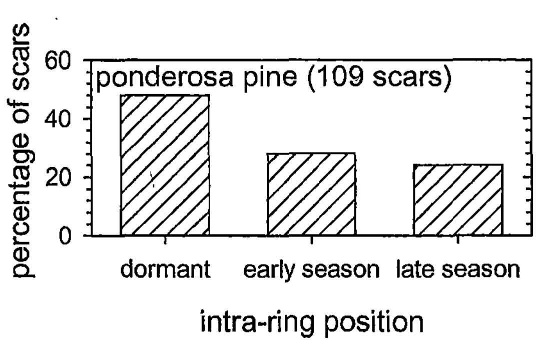


Figure 101. Intra-ring position of fire scars at PSG (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only species that comprised >10% of trees are plotted. We also dated scars from some Douglas-fir, white fir, Engelmann spruce and limber pine, but these species yielded too few scars with an intra-ring position to plot here.

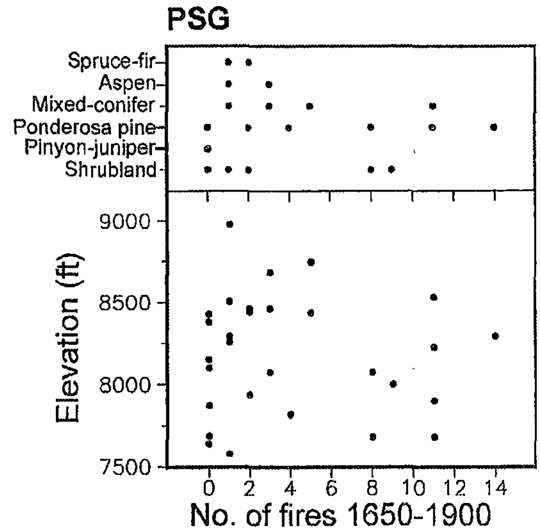
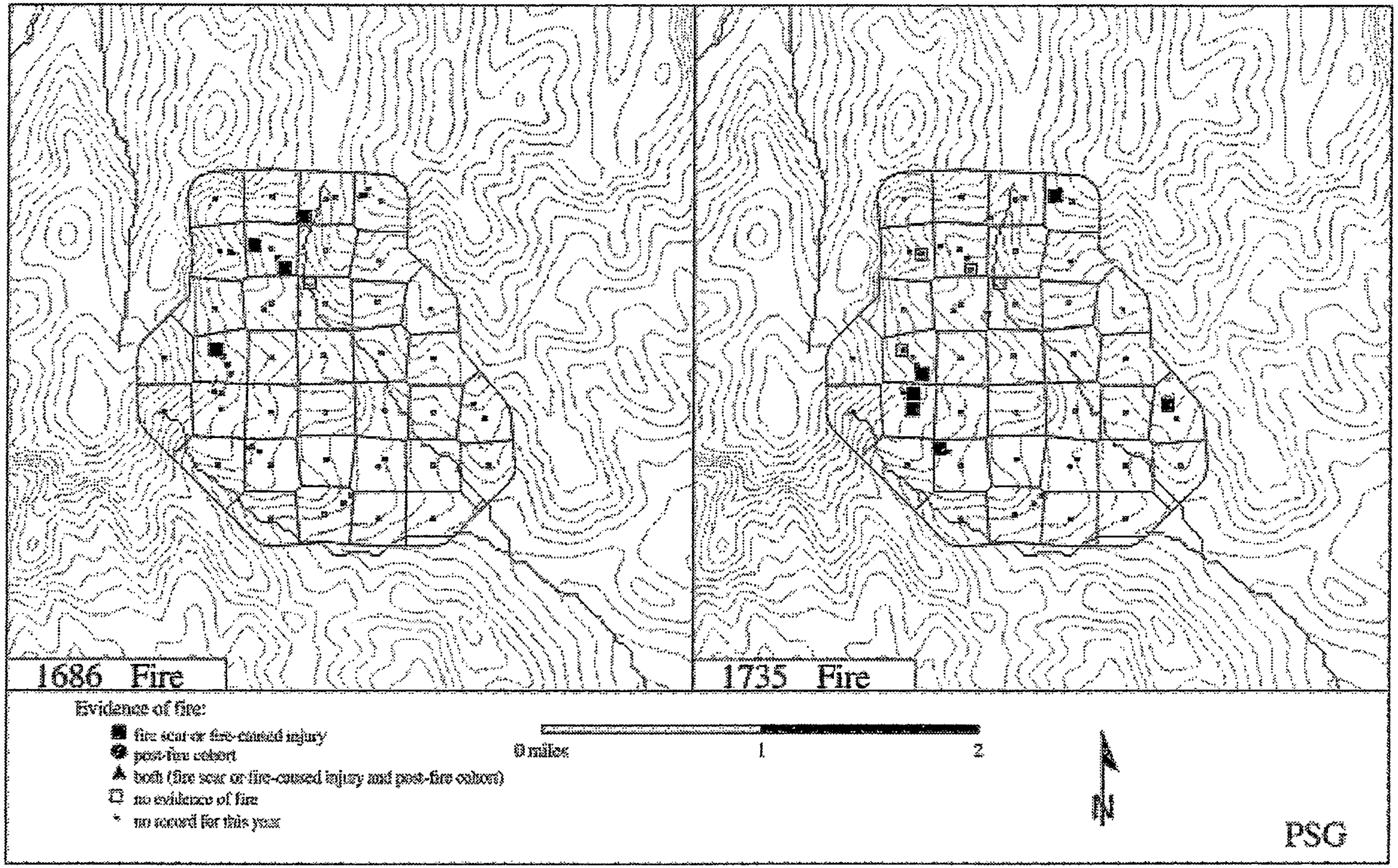
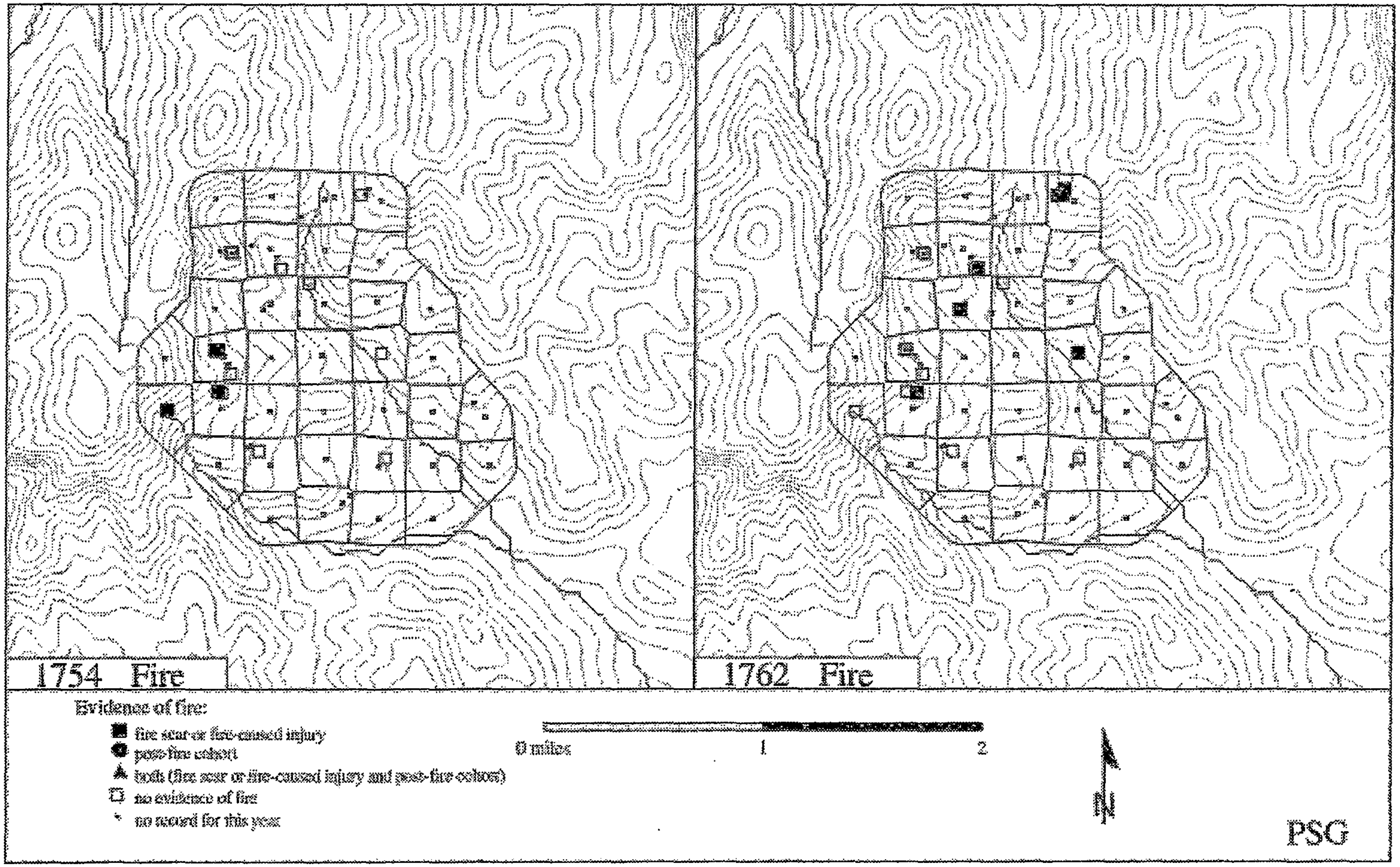


Figure 102. Number of fires within cells at PSG (1650-1900), by forest type (top panel, Table 2) and elevation (bottom panel). Number of fires includes only those fire years which were recorded on ≥2 trees at a site.

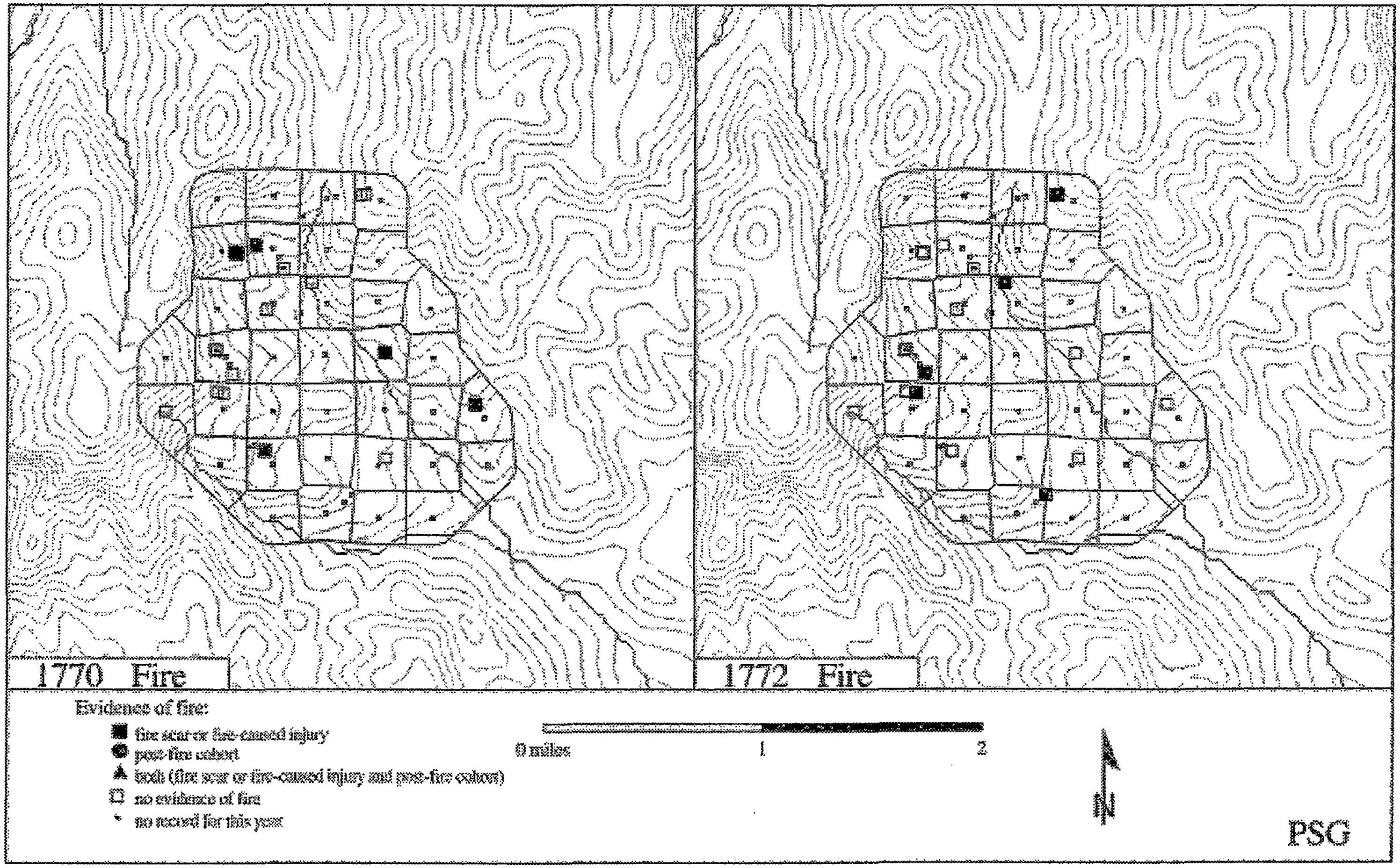
Maps of surface fires at PSG

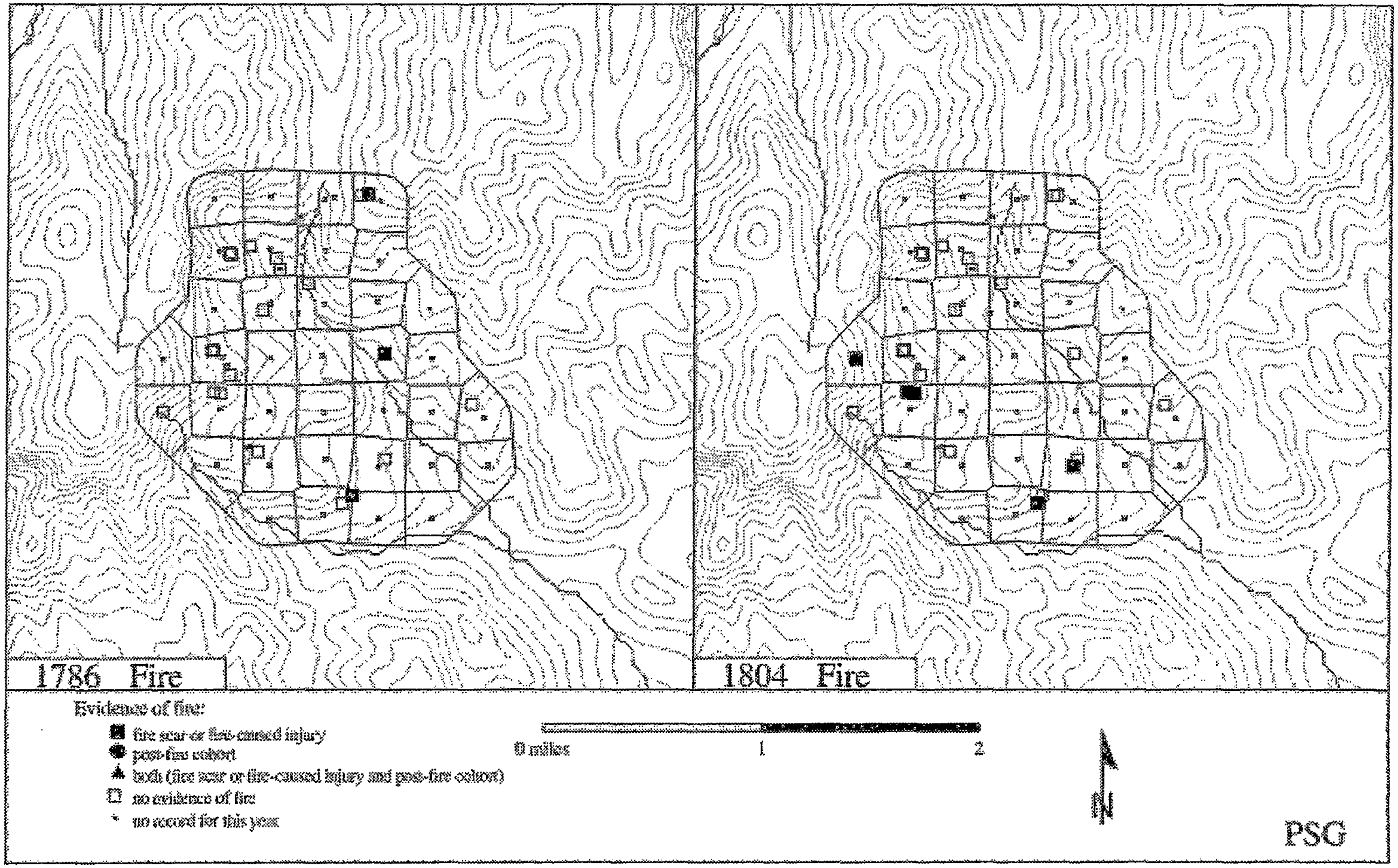
The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.


1686 Fire
1735 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
PSG

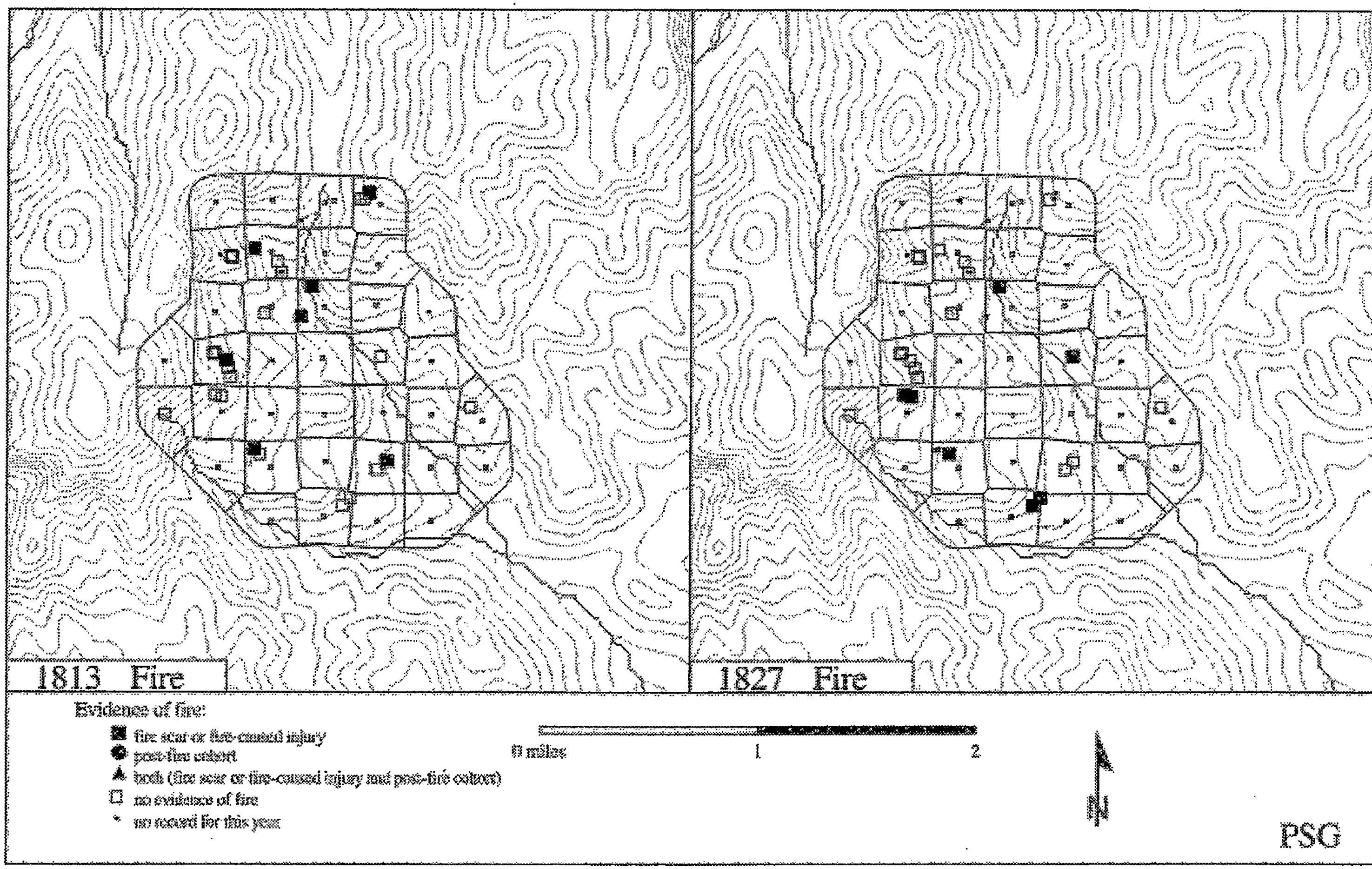


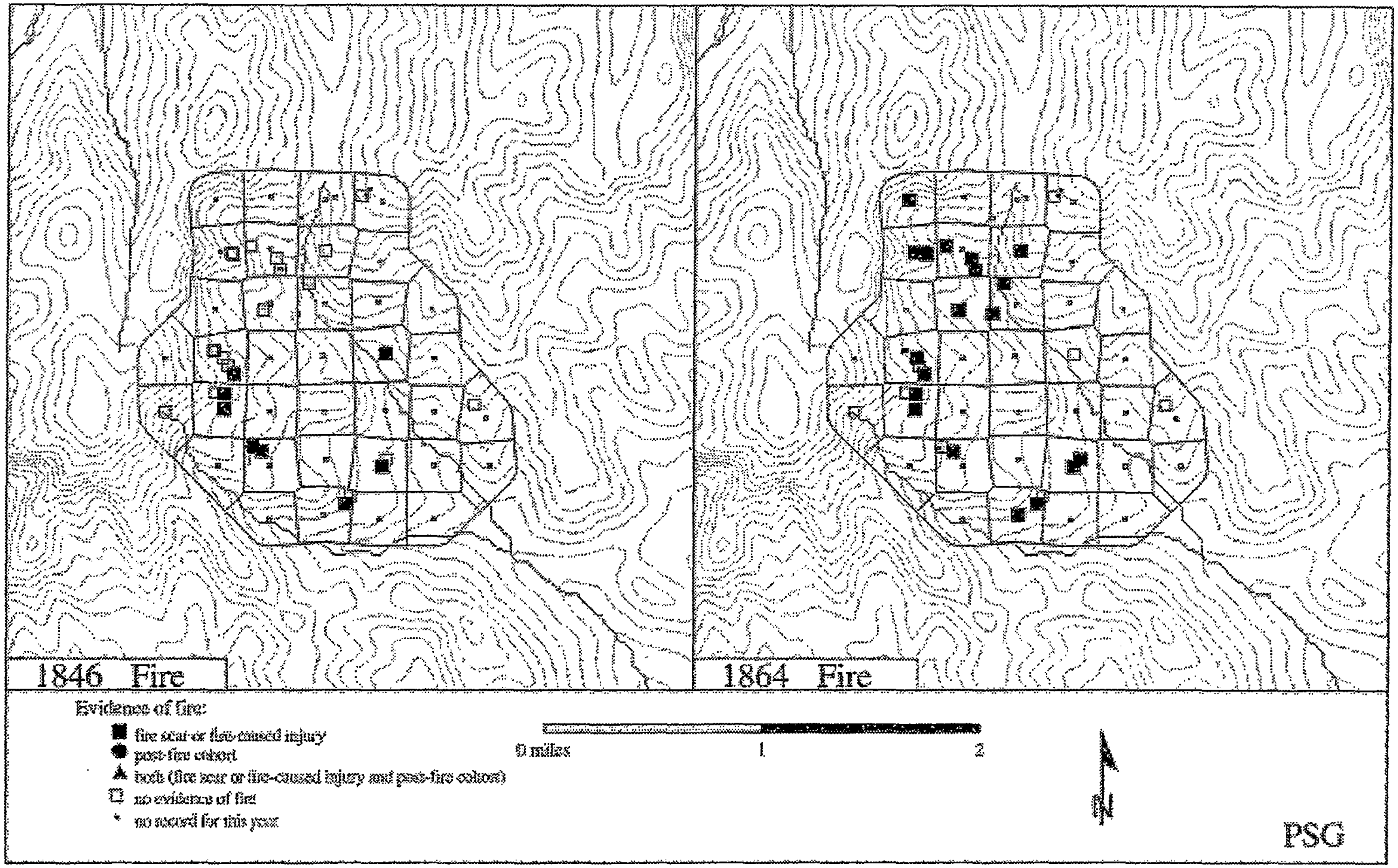
1754 Fire
1762 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
PSG

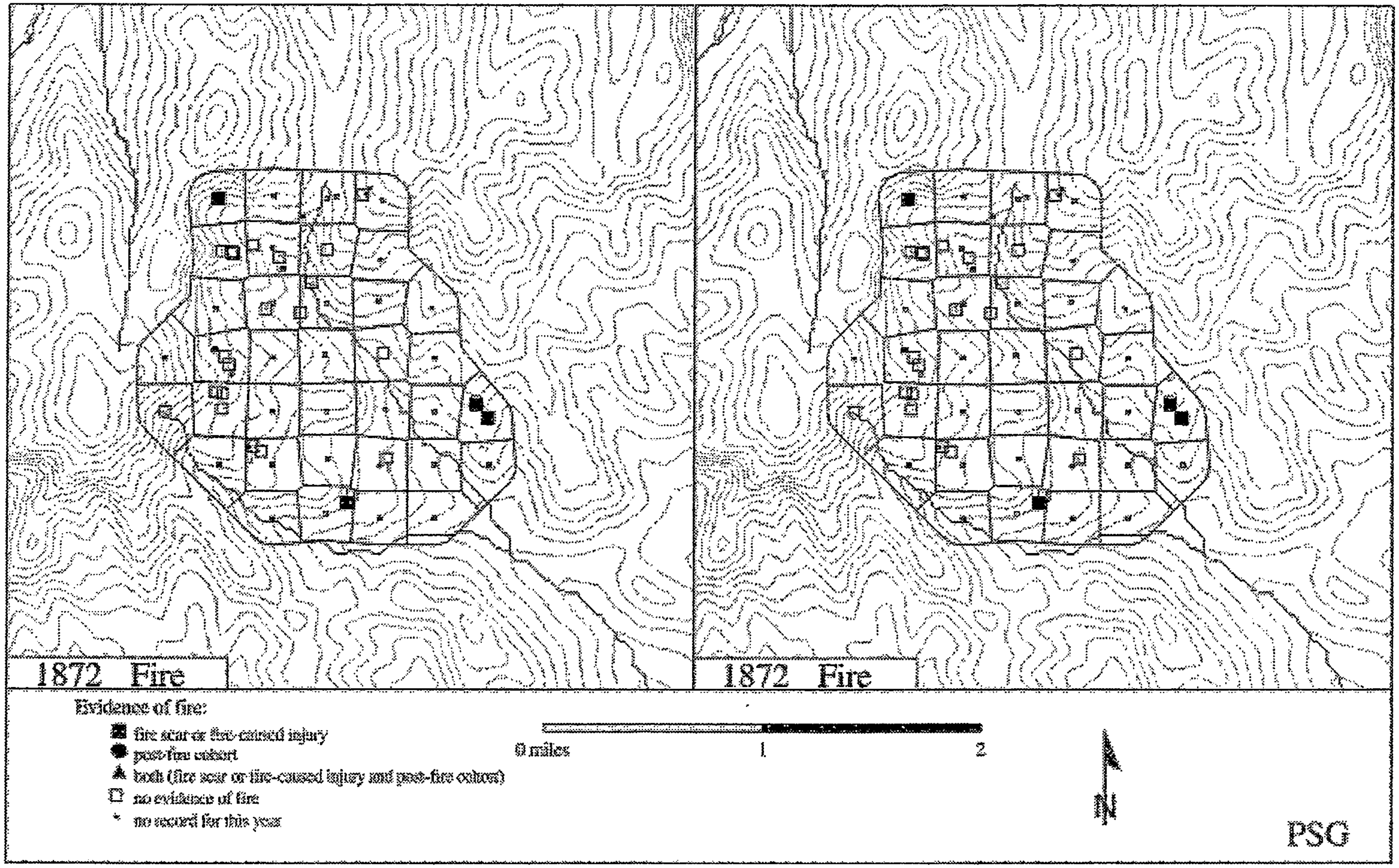

1770 Fire
1772 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
PSG



1786 Fire
1804 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
PSG


1813 Fire
1827 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
PSG


1846 Fire
1864 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
PSG


1872 Fire
1872 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
PSG

BOULDER MOUNTAIN - DIXIE NATIONAL FOREST (BOM)

Study Area

We sampled a grid of 30 plots over 1226 acres near Spring Creek, on the Teasdale Ranger District of the Dixie National Forest in Wayne county, Utah (Figure 103). The plots ranged in elevation from 7890 to 11075 ft, and slope from 0-47%. The plots were sampled on a range of aspects, although most plots were on north or east aspects (77%, Figure 104). The topography of the plots we sampled was generally similar to that of the sampling area at this site, except that we slightly undersampled plots with low slopes and over sampled those with moderate slopes.

Results

Tree recruitment

Our plots included 892 total trees (75% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 859 trees and were able to crossdate most of these (788 trees, or 92% of sampled trees). The trees that occurred on our plots included a range of species (Figure 105). Trees were recruited into the sampled plots between 1346 and 1971, although most trees (80%) were recruited after 1750 (Figure 106).

Average tree density was higher at plots in 2000 than in 1860 for all 6 of the forest types that we assigned to the sampled plots at this site (pinyon-juniper, ponderosa, mixed conifer, aspen-mixed conifer, aspen and spruce-fir, Figure 107, Table 2).

Surface fires

We removed fire-scarred sections from a total of 132 trees at BOM. We sampled most of these (78%) in the 25 of our 30 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were ponderosa pine (52%), Engelmann spruce (32%) or Douglas-fir (9%), but we also sampled a few fire-scarred aspen, two-needle pinyon and Utah juniper. Most of the trees we sampled were logs, snags or stumps (70%), with the rest live trees. We were unable to crossdate sections from some of the sampled trees (9%). Those that we did crossdate yielded 441 fire scars, and 23 eroded fire scars or abrupt changes in ring width (1341 to 2004; Figure 108). We were able to assign an intra-ring position to 60% of the fire scars. Most of the scars from the analysis period (1650-1900) were created by fires burning early in the cambial growing season or when the cambium was dormant (73% of assigned scars, Figure 109).

The number of surface fires during the analysis period (1650-1900) varied with elevation and forest type at BOM (Figure 110), with fires more frequent at low than high elevation, and in dry versus mesic forest types. Surface fires ceased in the late 1800s at this site (Figure 108).

Figures and tables for BOM

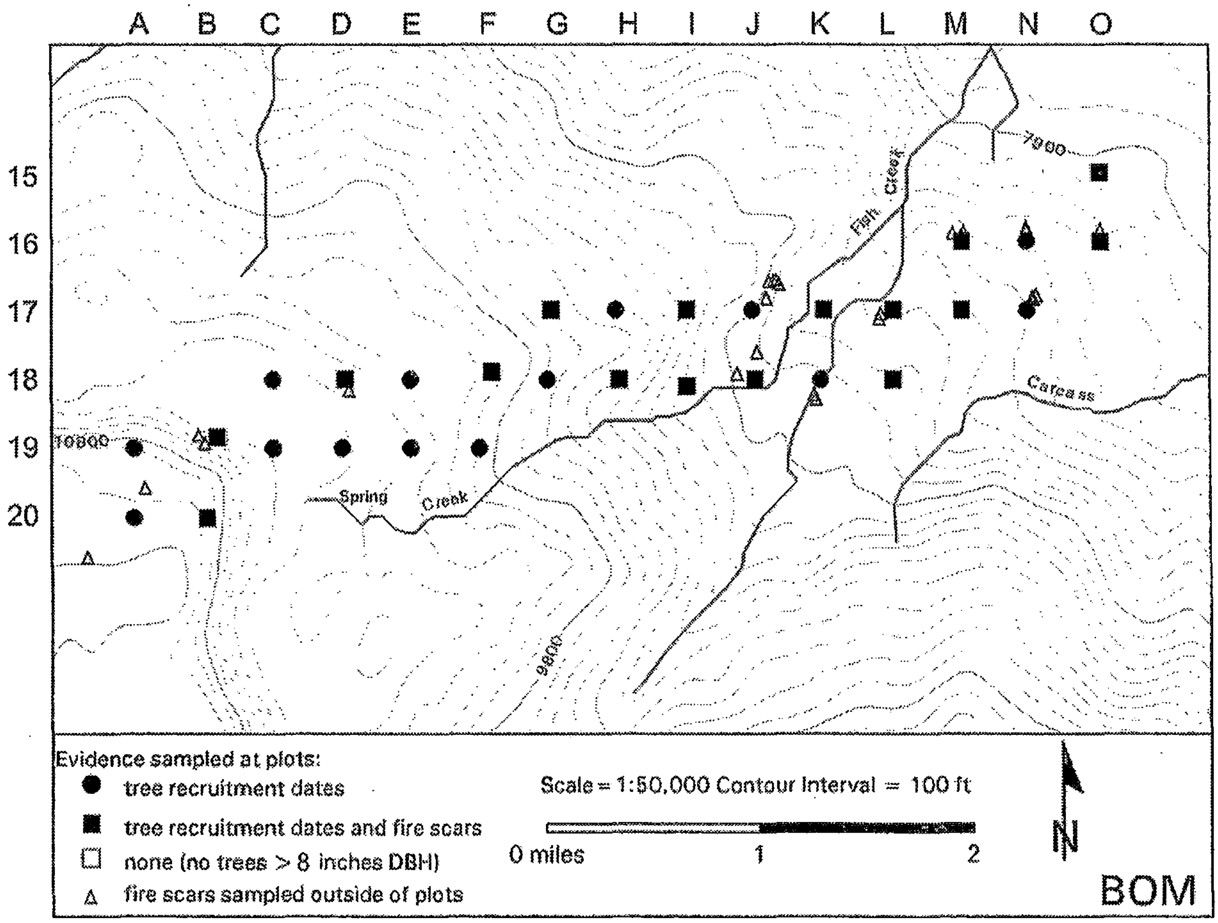


Figure 103. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the southwestern most plot is 20A, the next plot to the east is 20B, etc. Most of the fire-scarred trees (78% of 120 dated trees) were sampled within plots and so are not mapped individually.

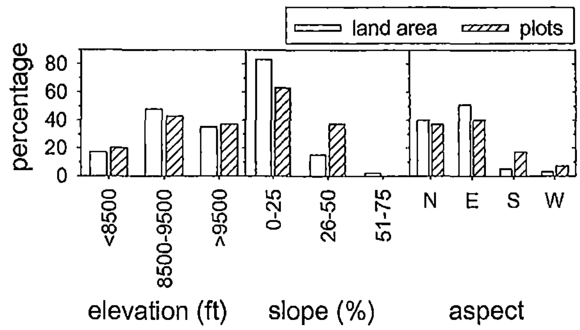


Figure 104. Distribution of topography for sampled plots and for land area at BOM. Aspect classes are 90° wide, beginning with 46° for east (E). Land area was derived from a digital elevation model.

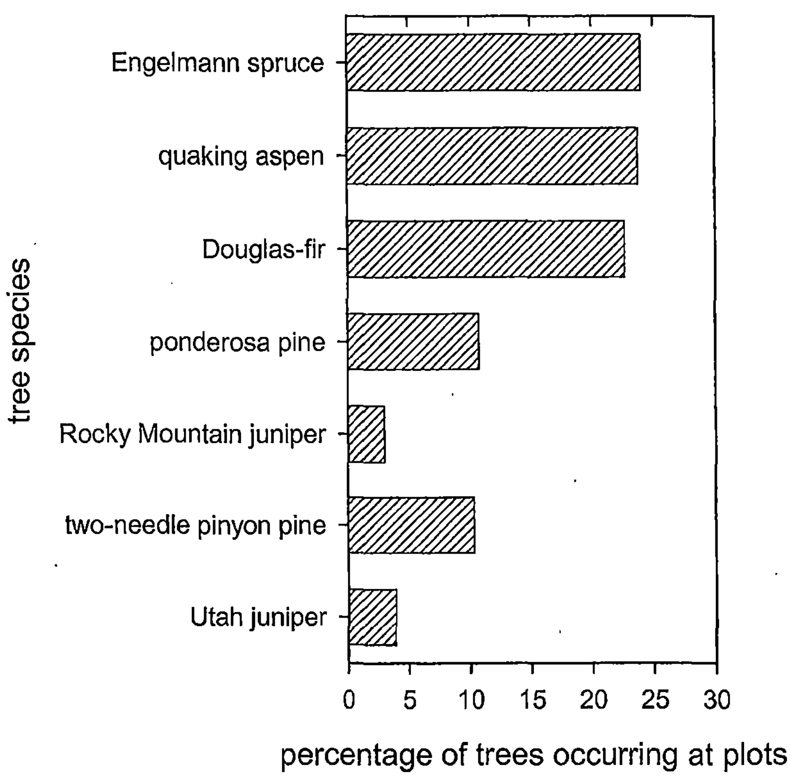


Figure 105. Species distribution of all trees that occurred in plots at BOM. In addition, 16 subalpine fir trees occurred in our plots but are not shown.

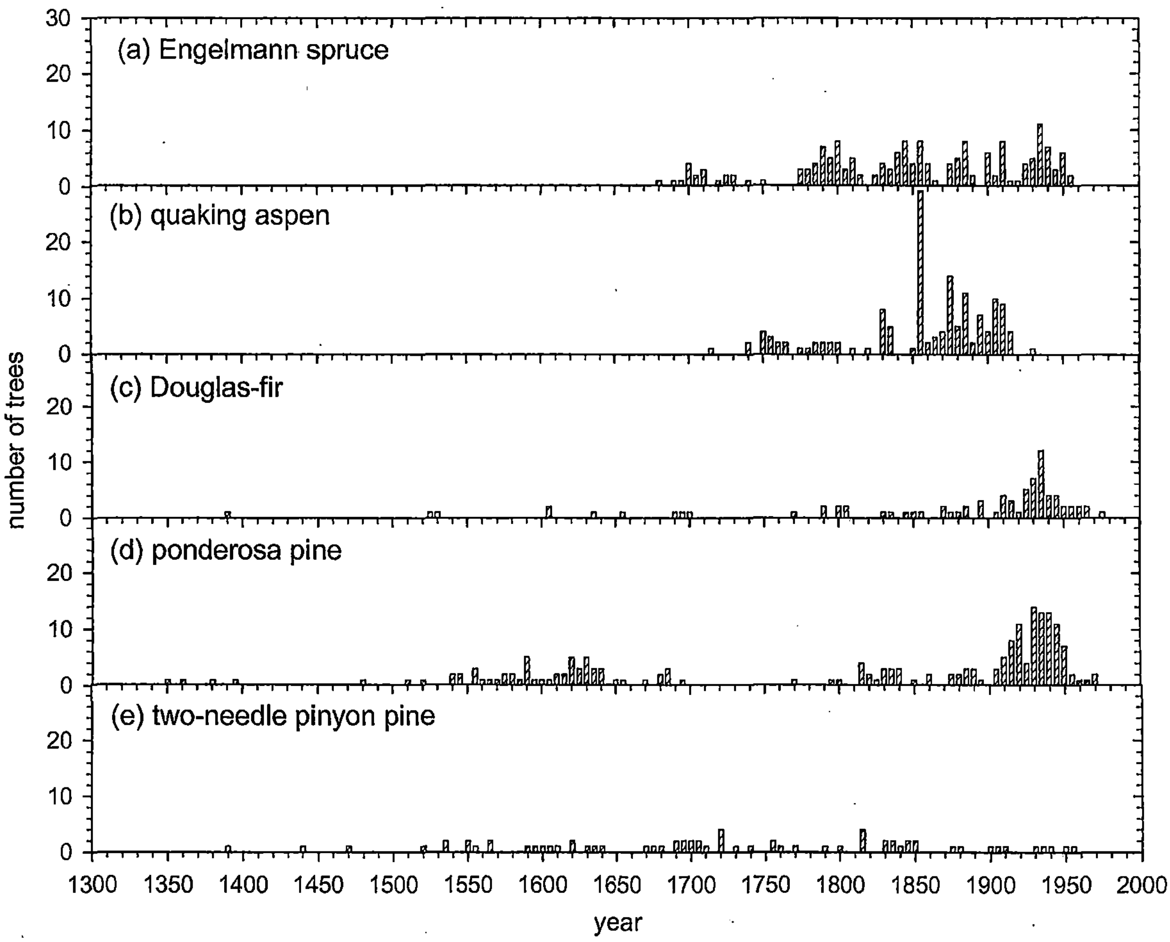


Figure 106. Distribution of tree-recruitment dates by species at BOM, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

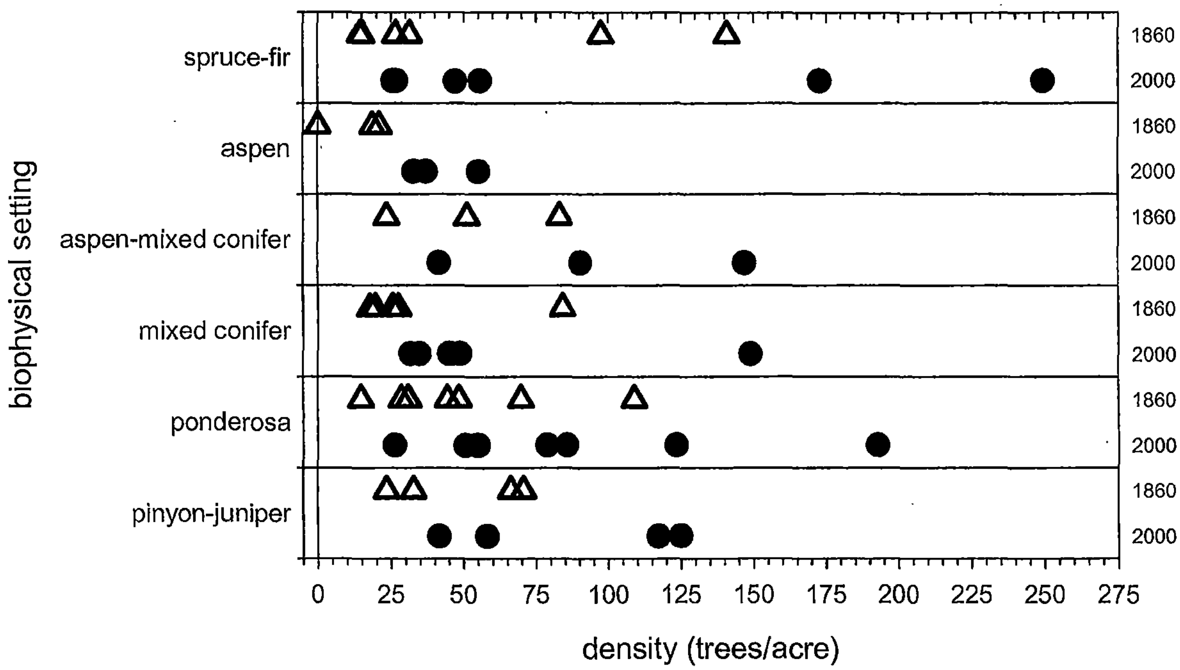


Figure 107. Density of live trees >8 inches DBH at each plot at BOM, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

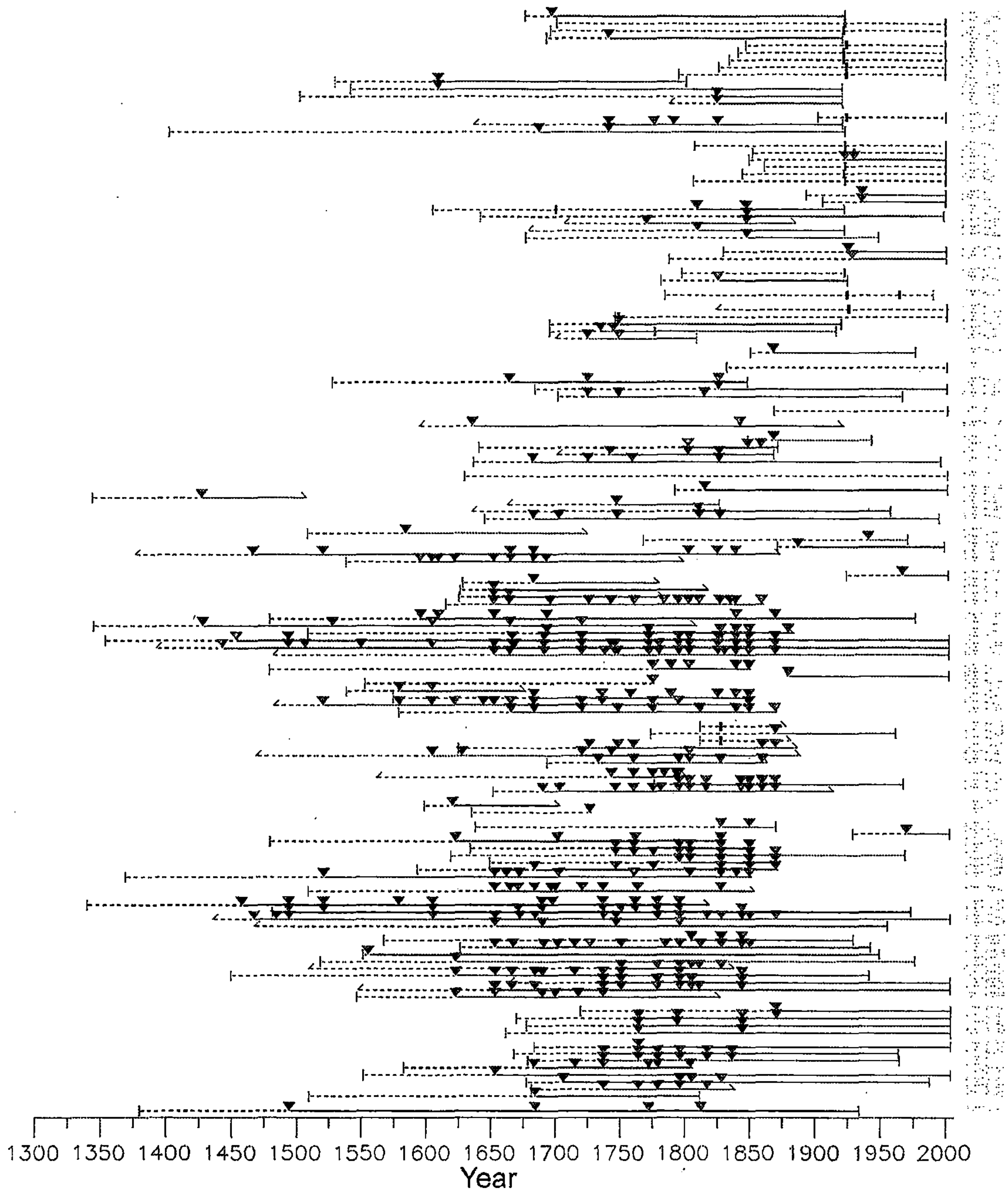


Figure 108. Fire chronologies at BOM, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

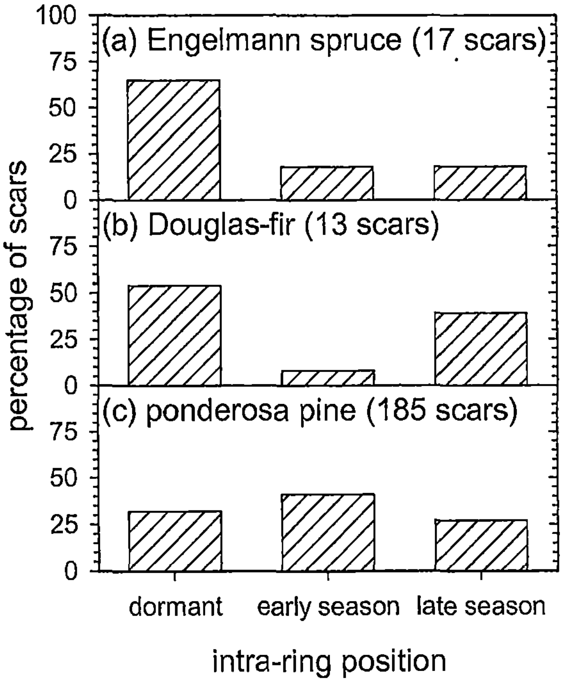


Figure 109. Intra-ring position of fire scars at BOM (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only species that comprised >10% of trees are plotted. We also dated scars from some quaking aspen, two-needle pinyon and Utah juniper, but these species yielded too few scars with an intra-ring position to plot here.

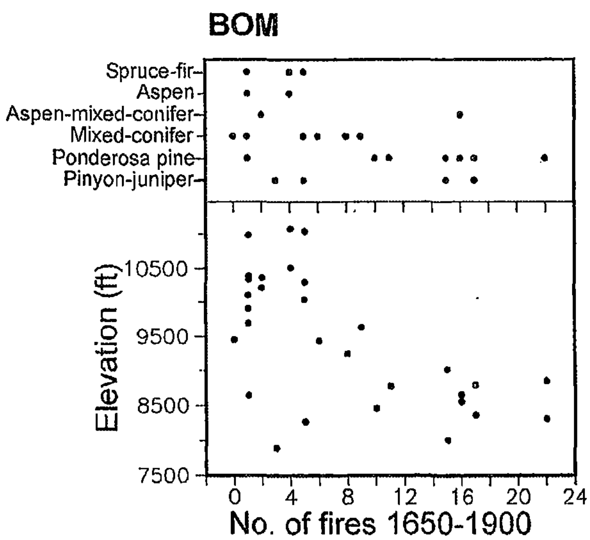
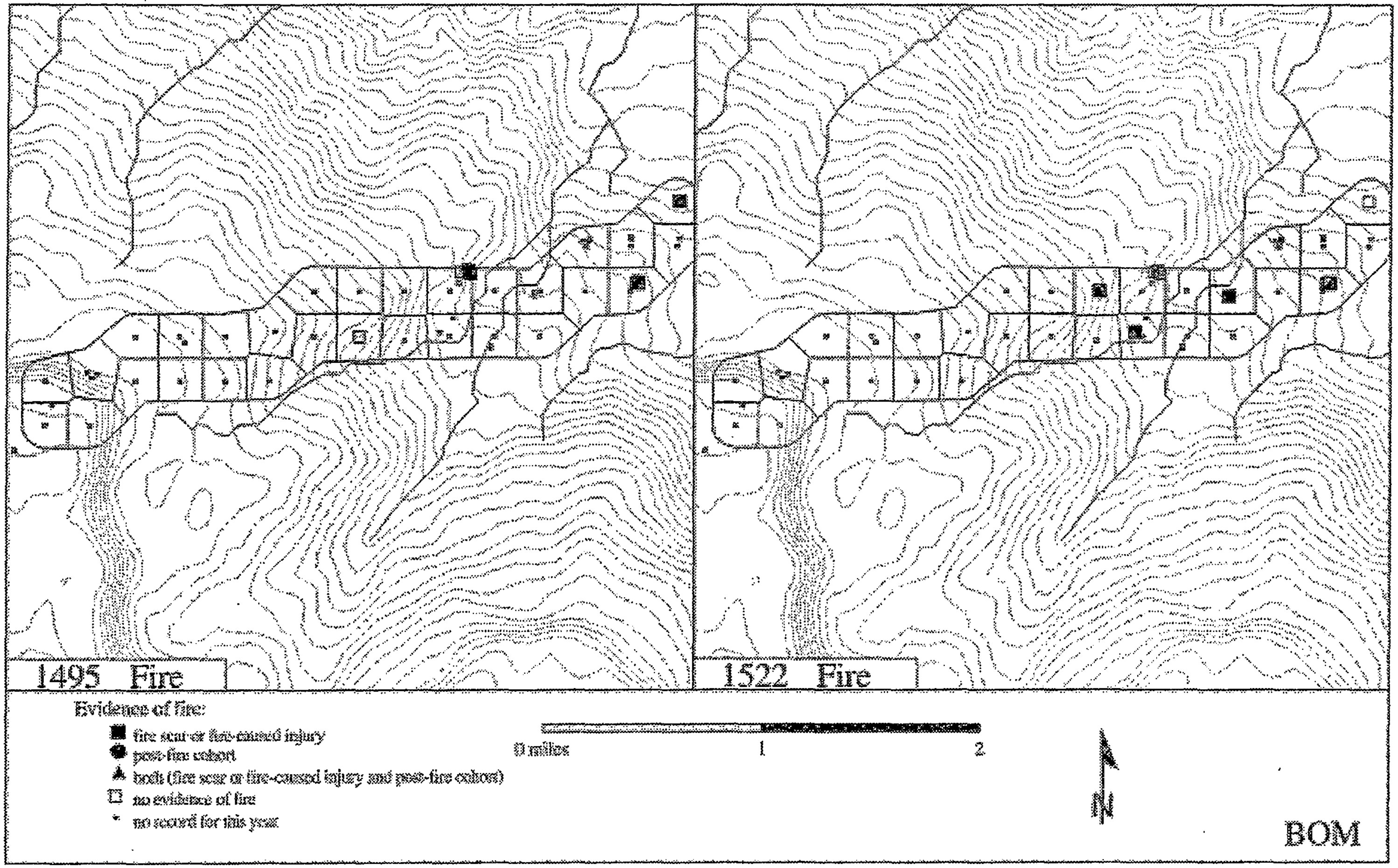
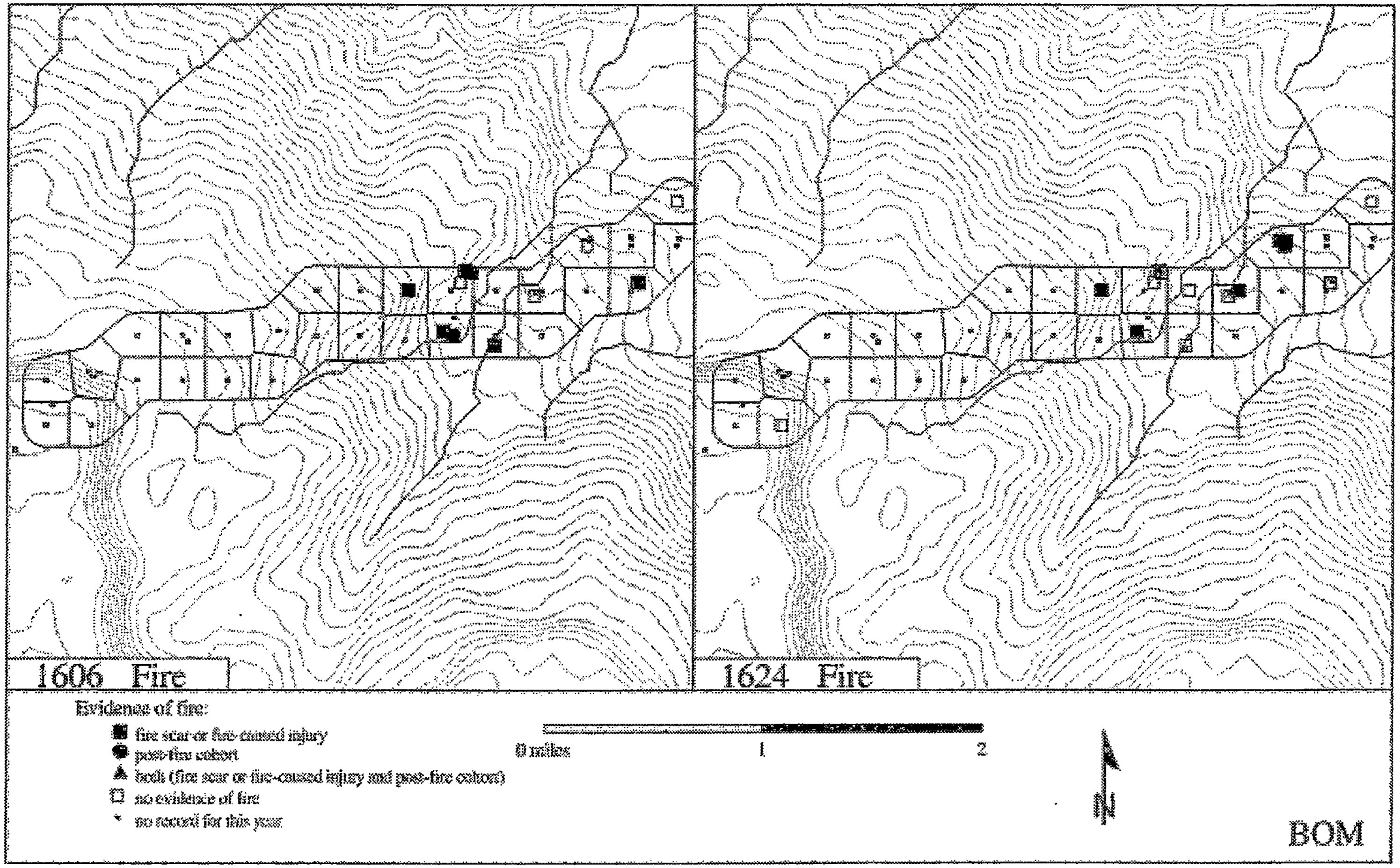


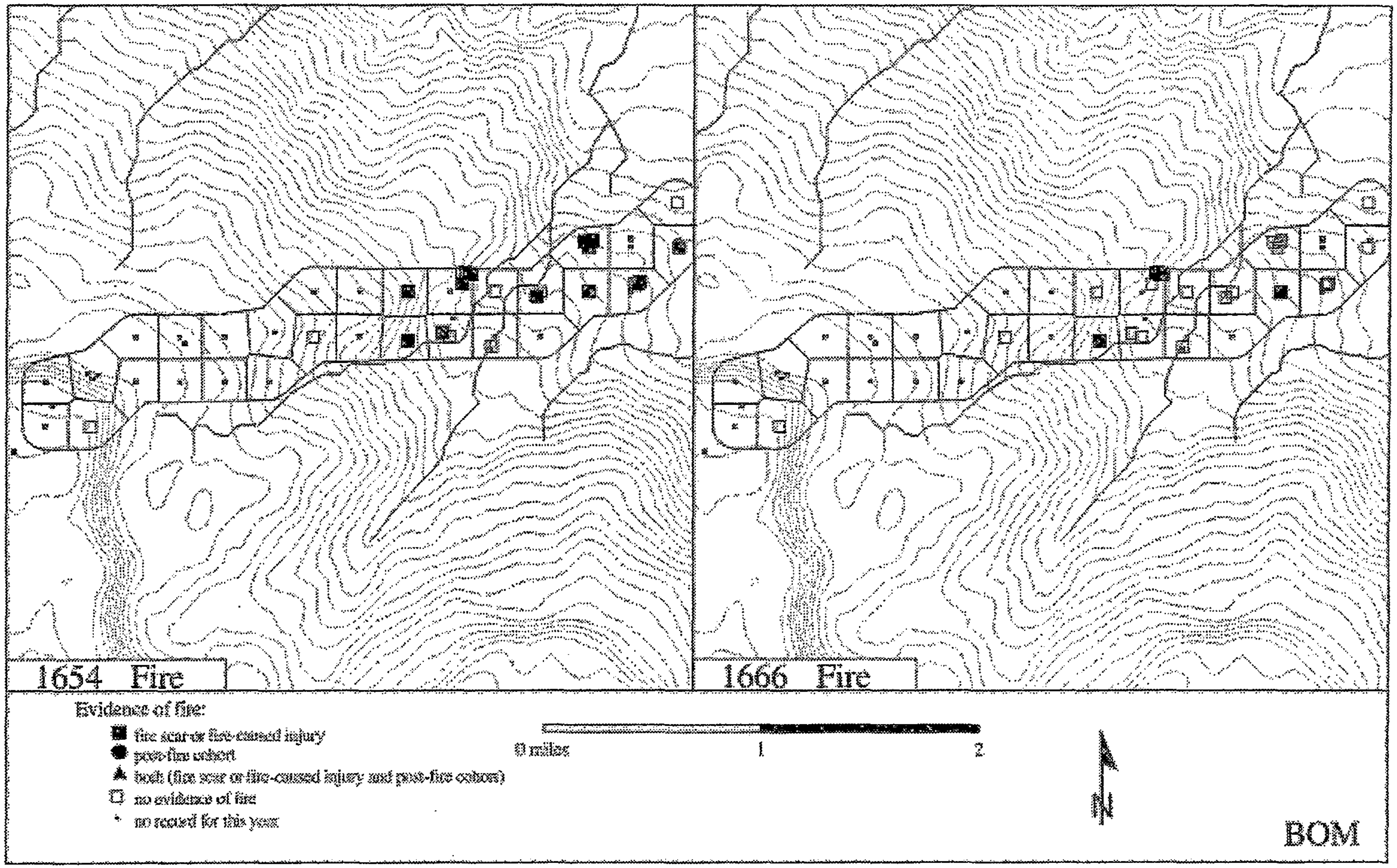
Figure 110. Number of fires within cells at BOM (1650-1900), by forest type (top panel, Table 2) and elevation (bottom panel). Number of fires includes only those fire years which were recorded on ≥2 trees at a site.

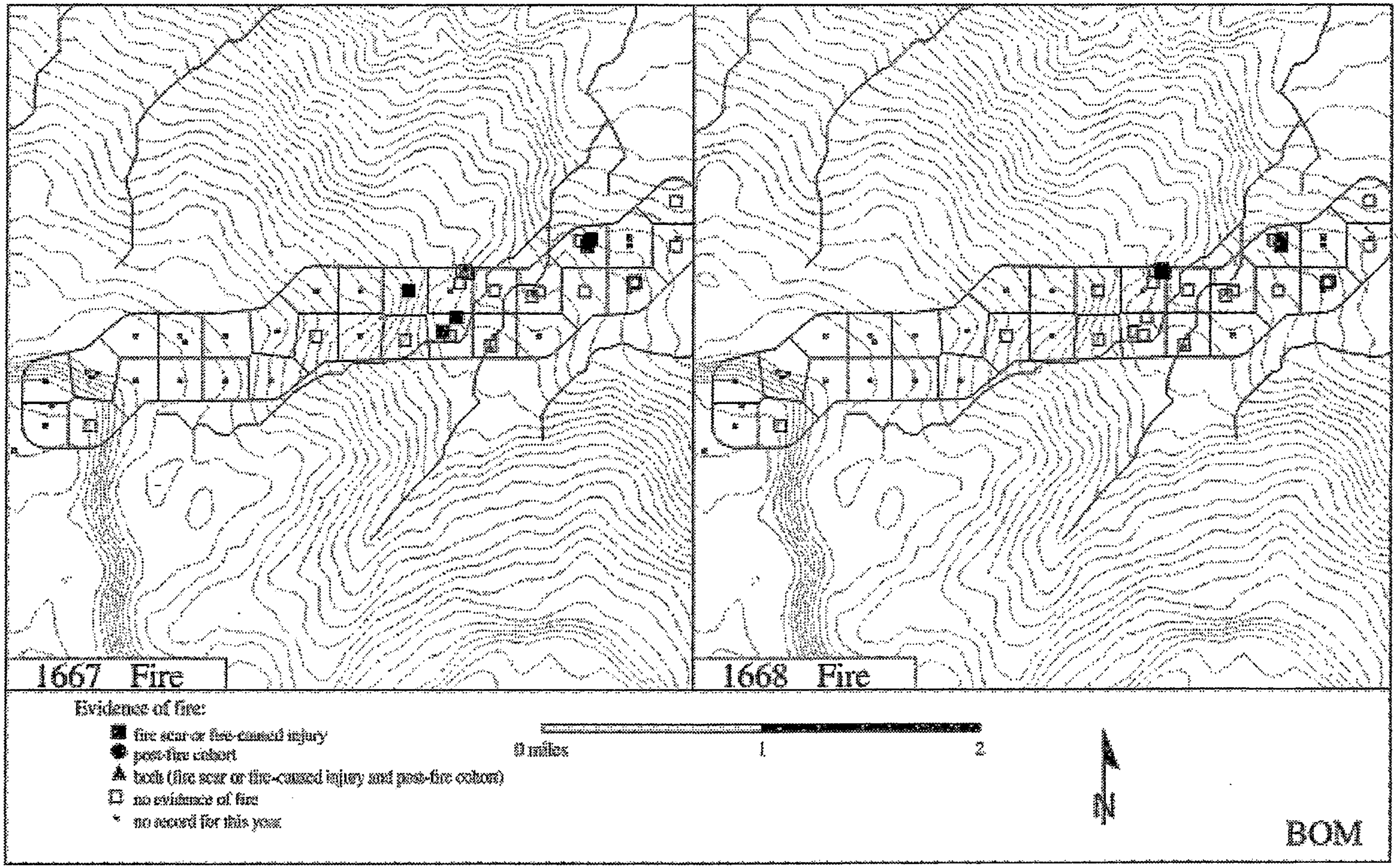
Maps of surface fires at BOM

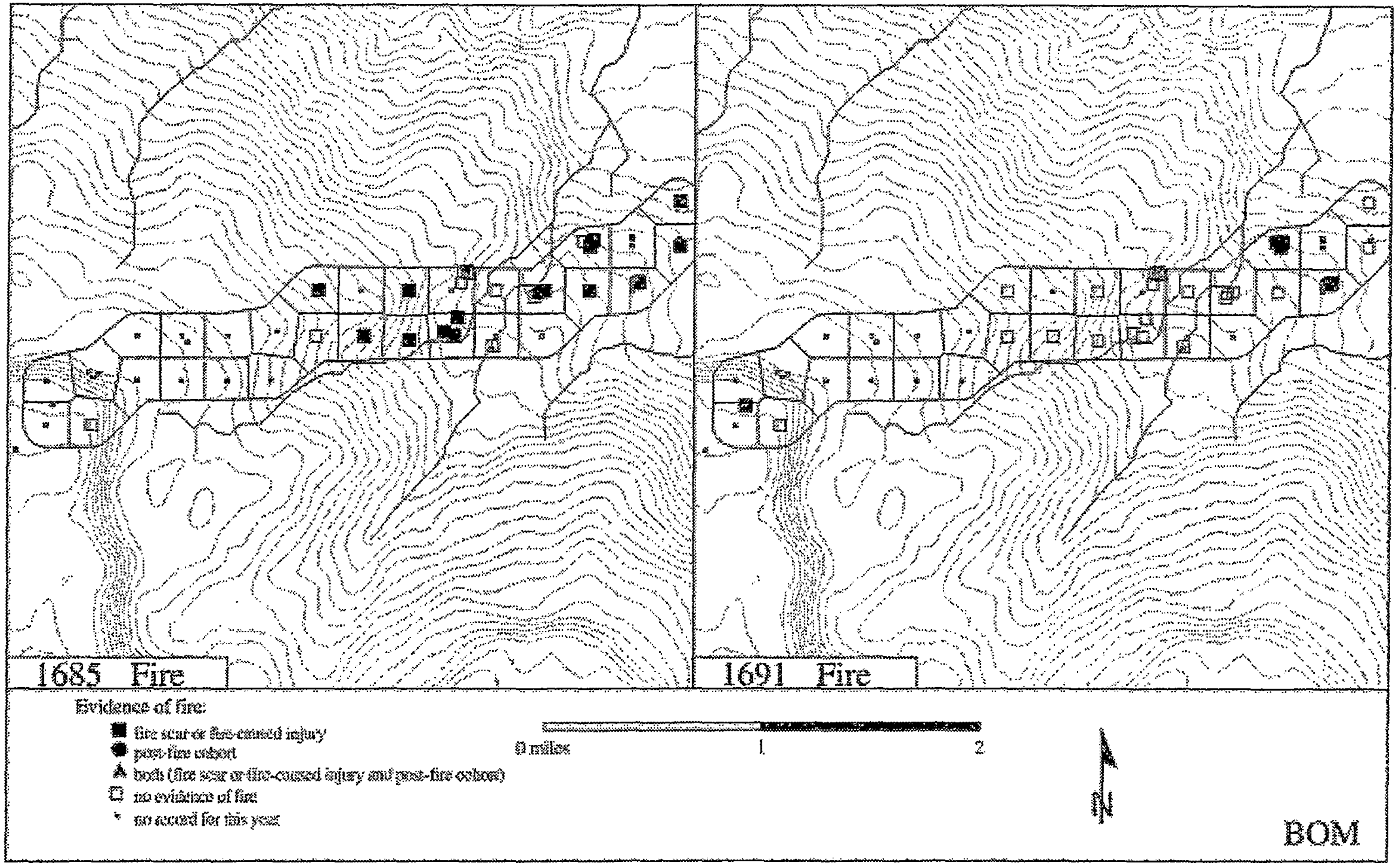
The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.

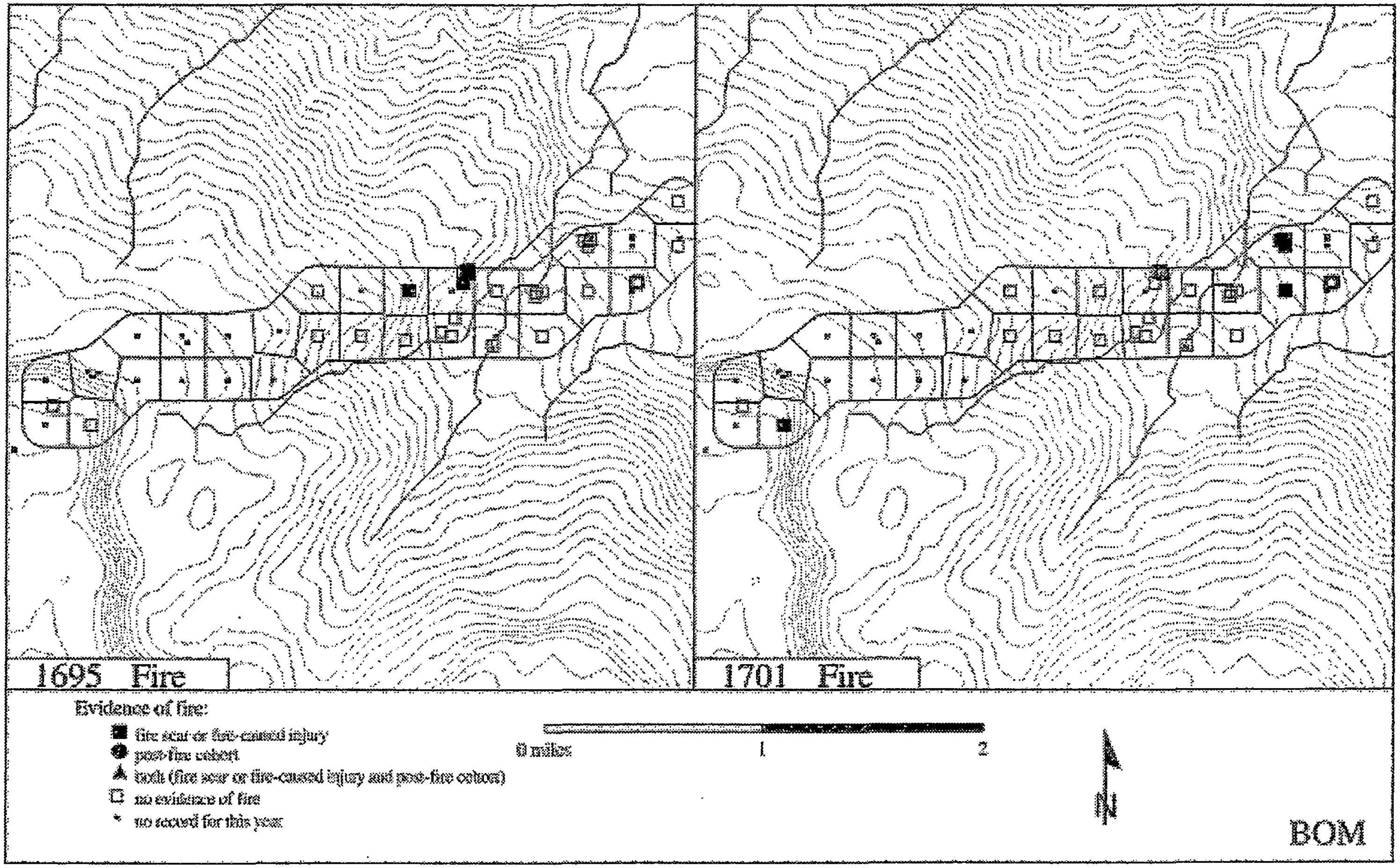

1495 Fire
1522 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

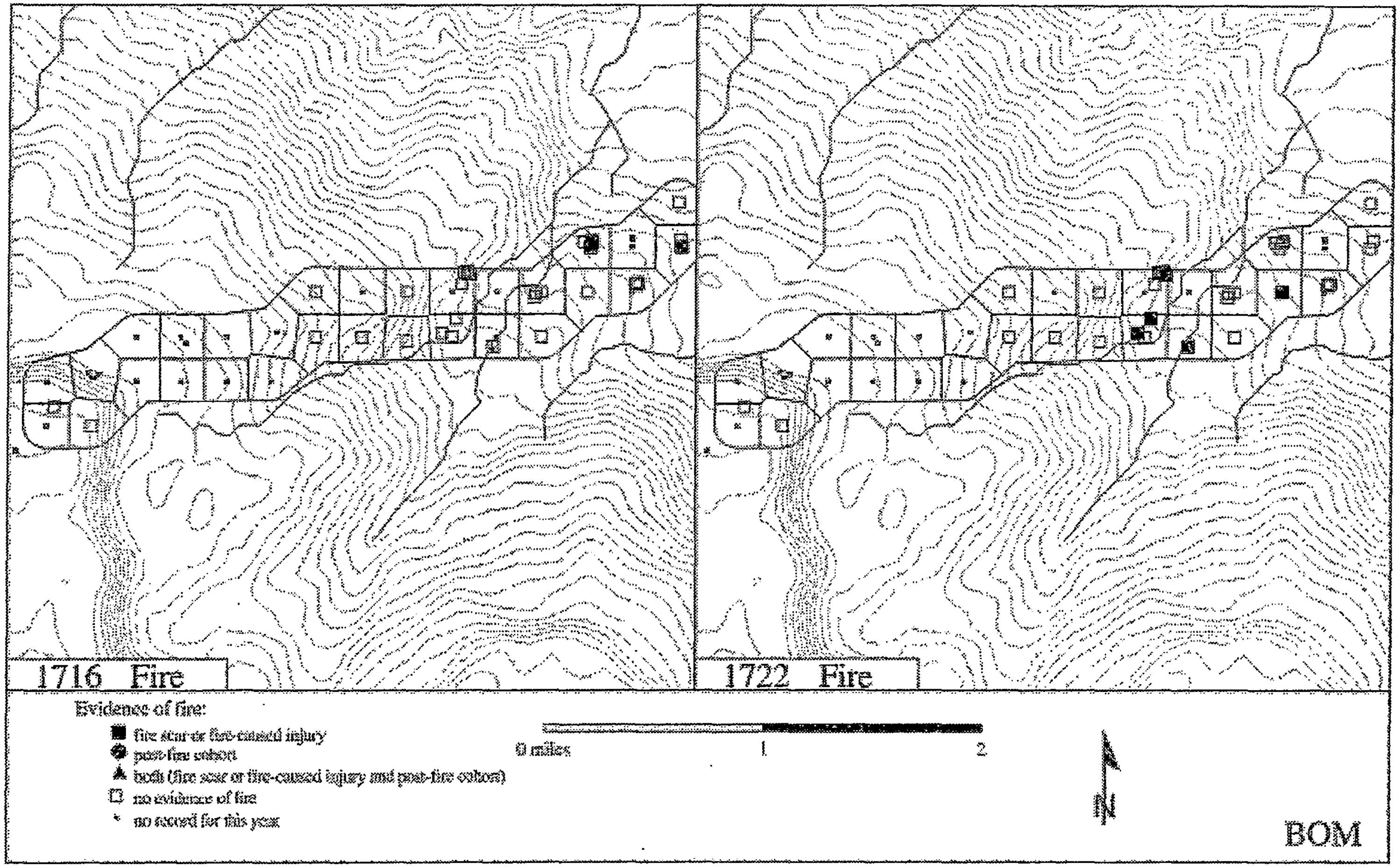

1606 Fire
1624 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

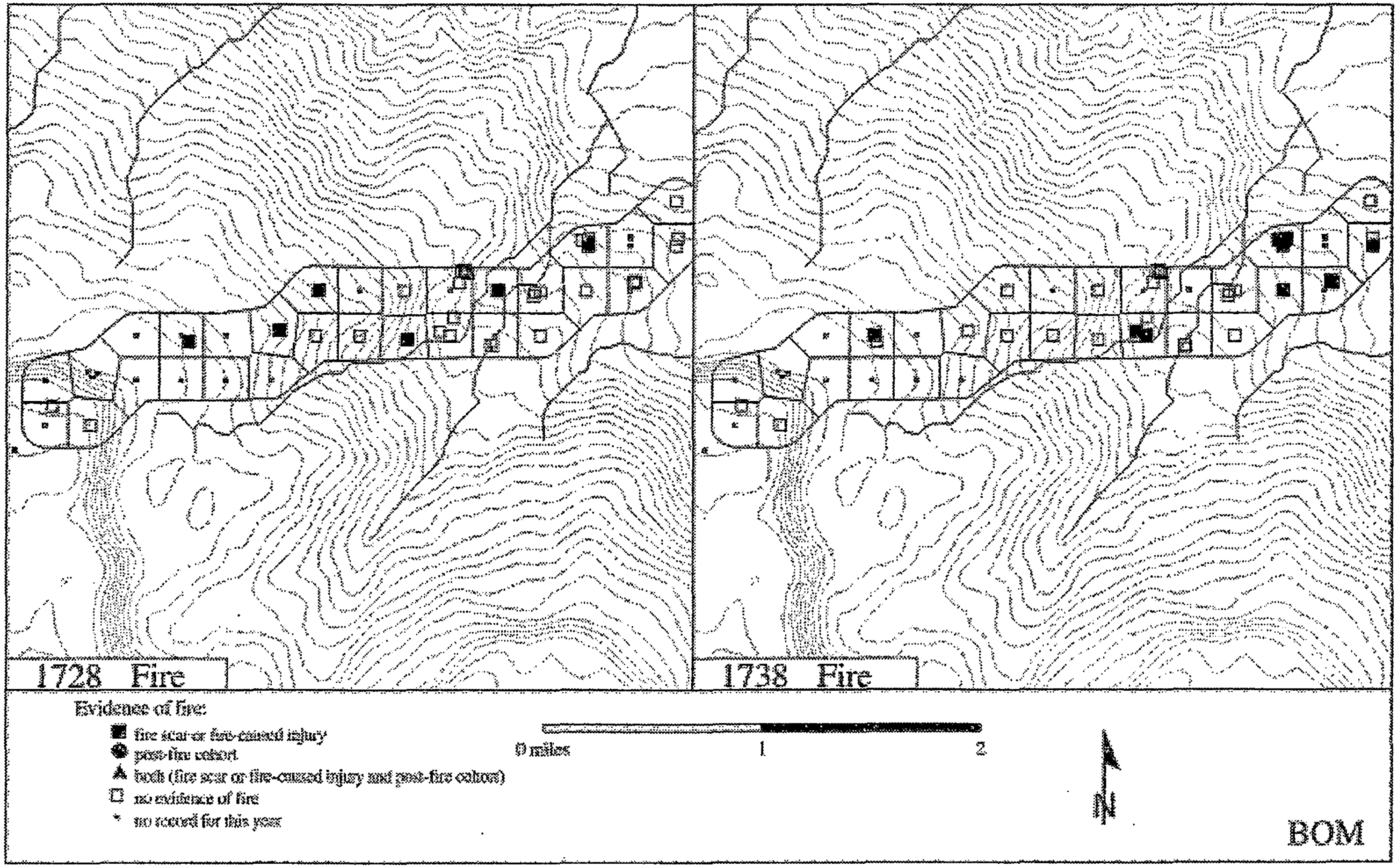

1654 Fire
1666 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

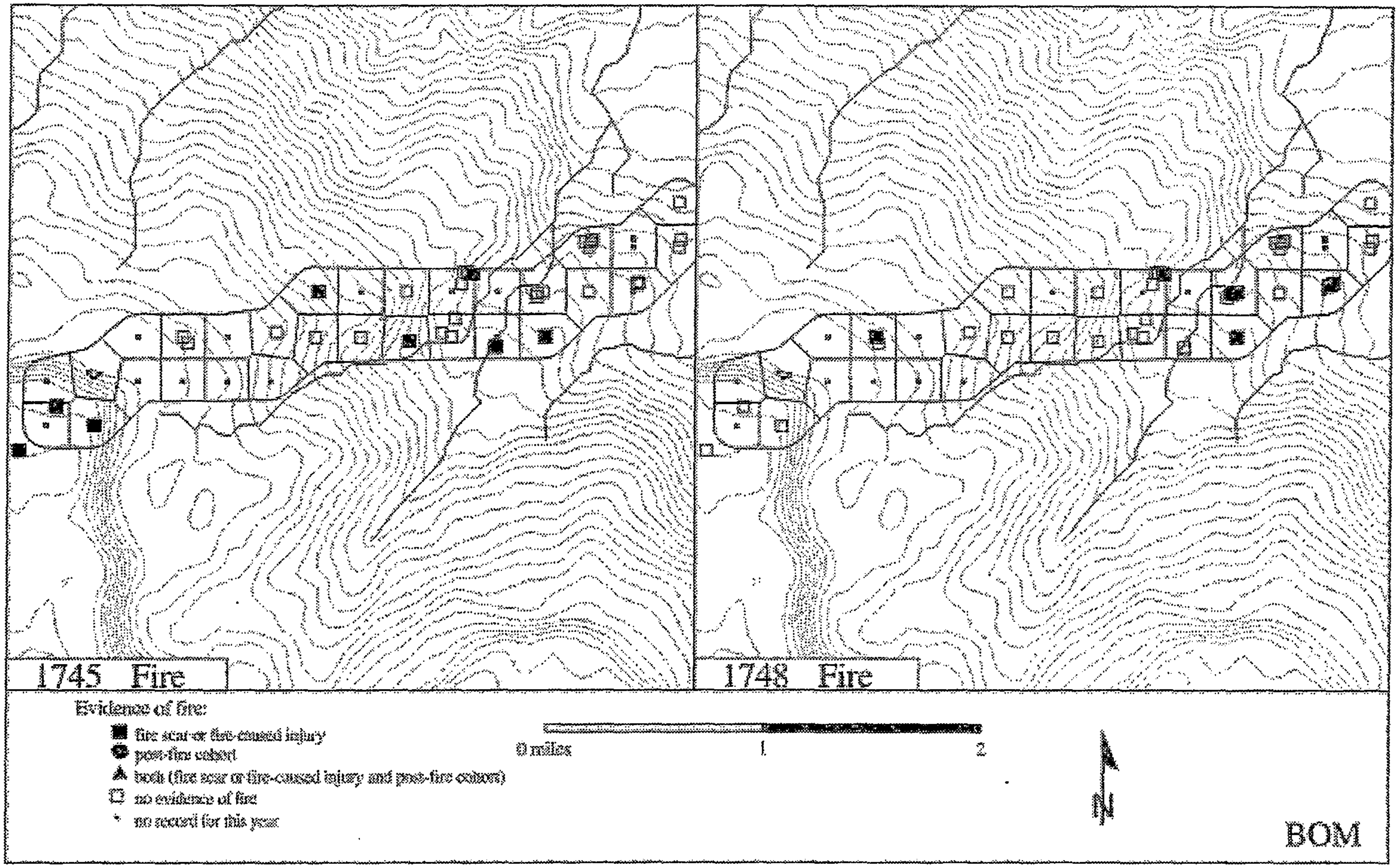

1667 Fire
1668 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

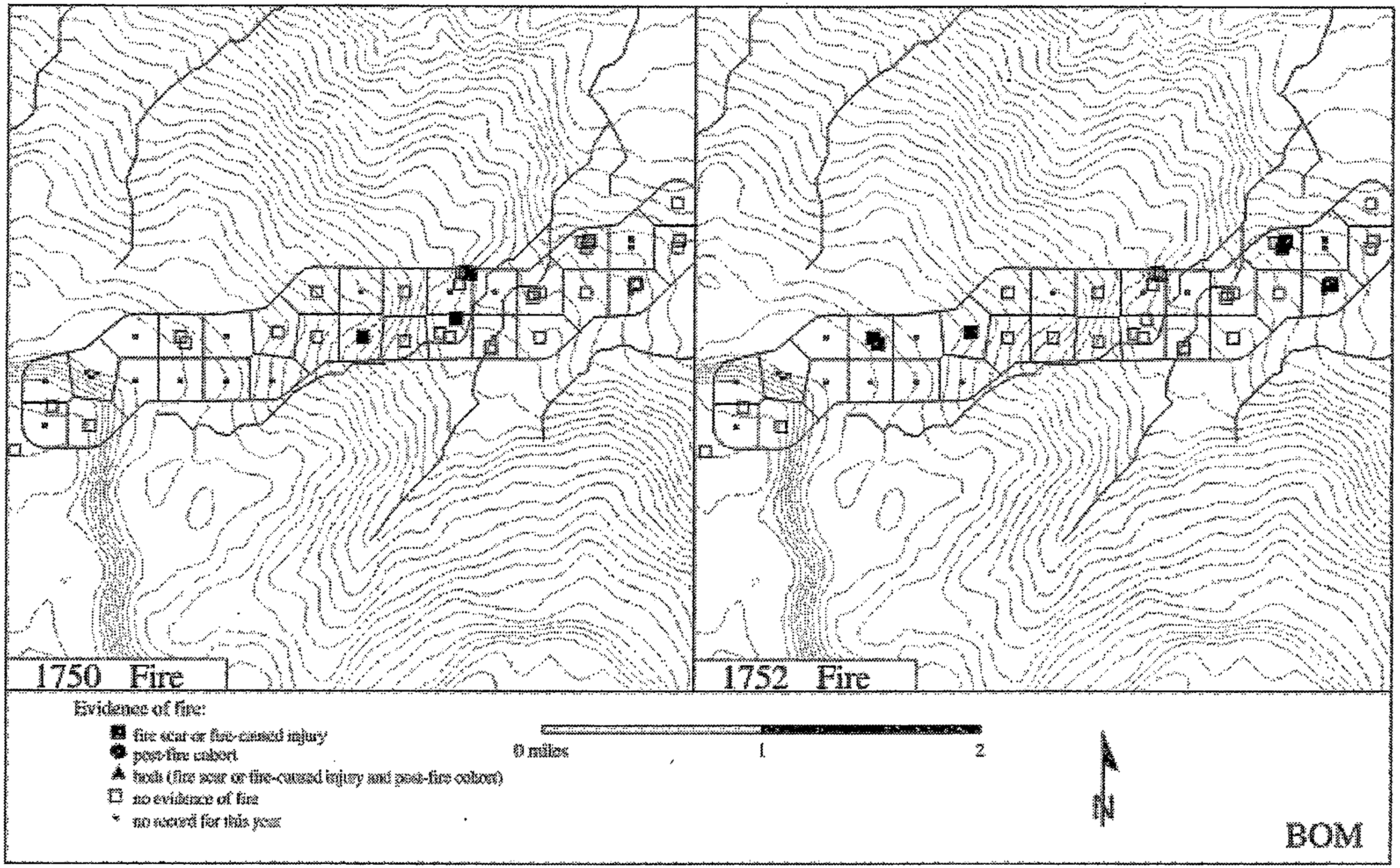

1685 Fire
1691 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

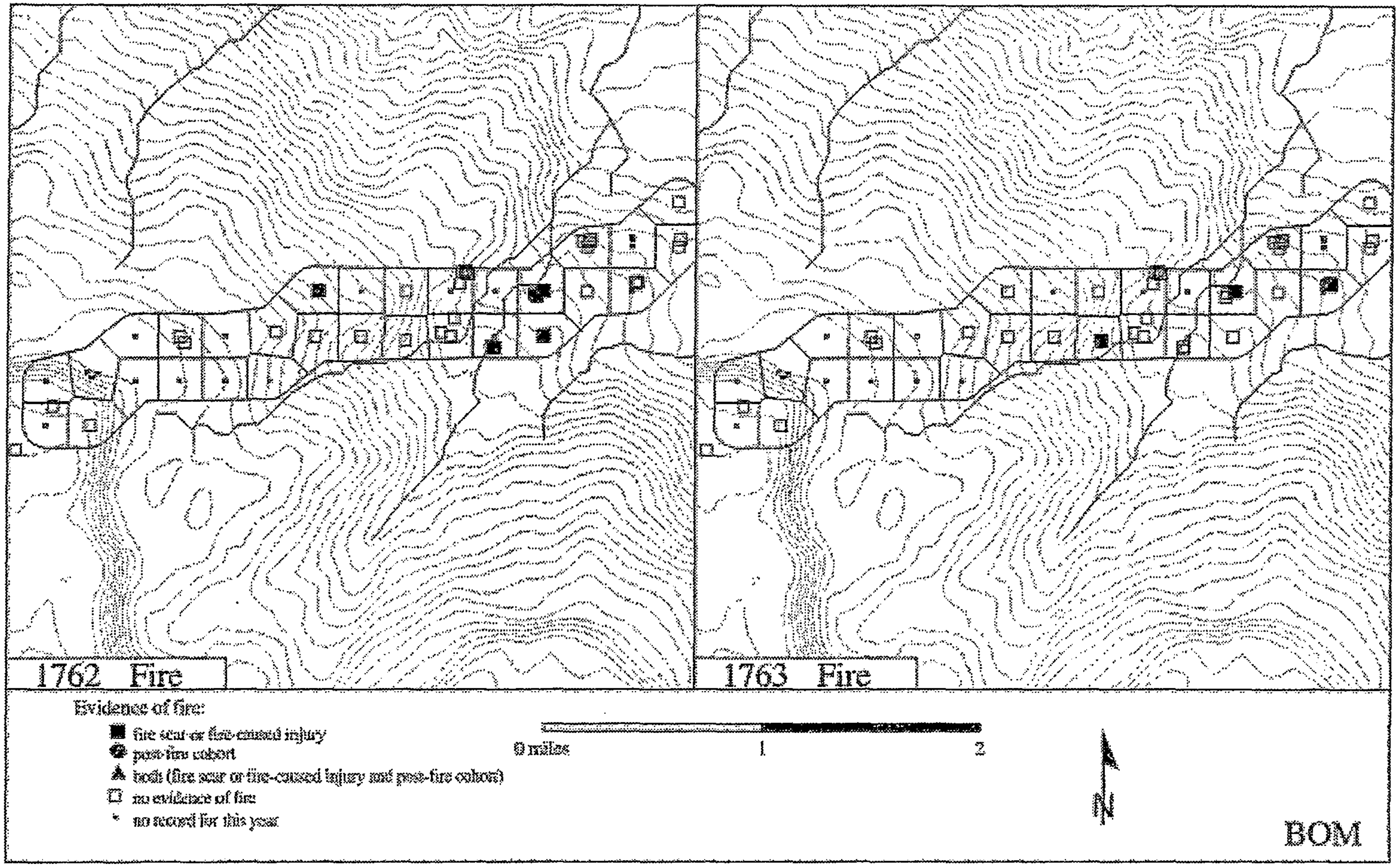

1695 Fire
1701 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

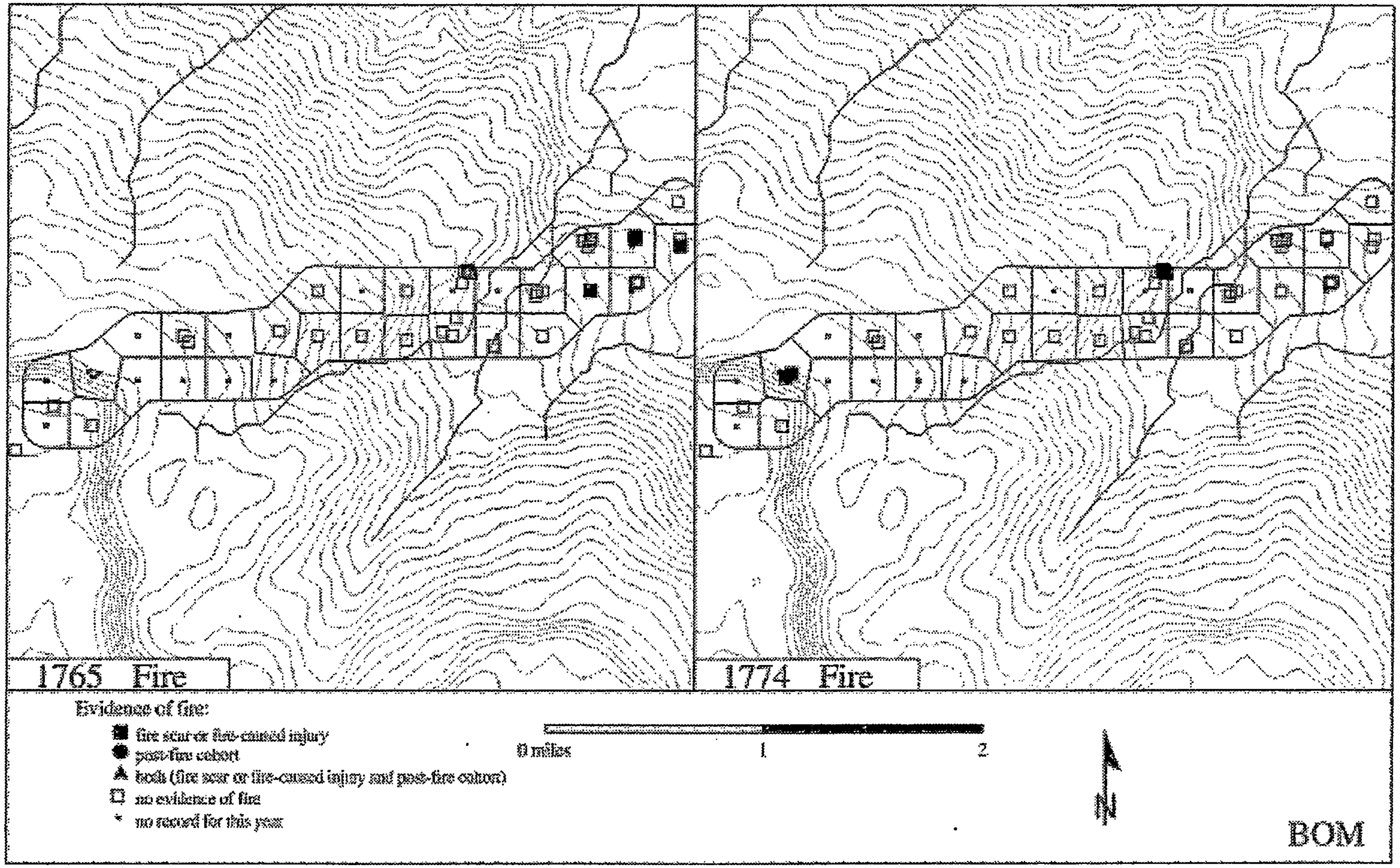

1716 Fire
1722 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

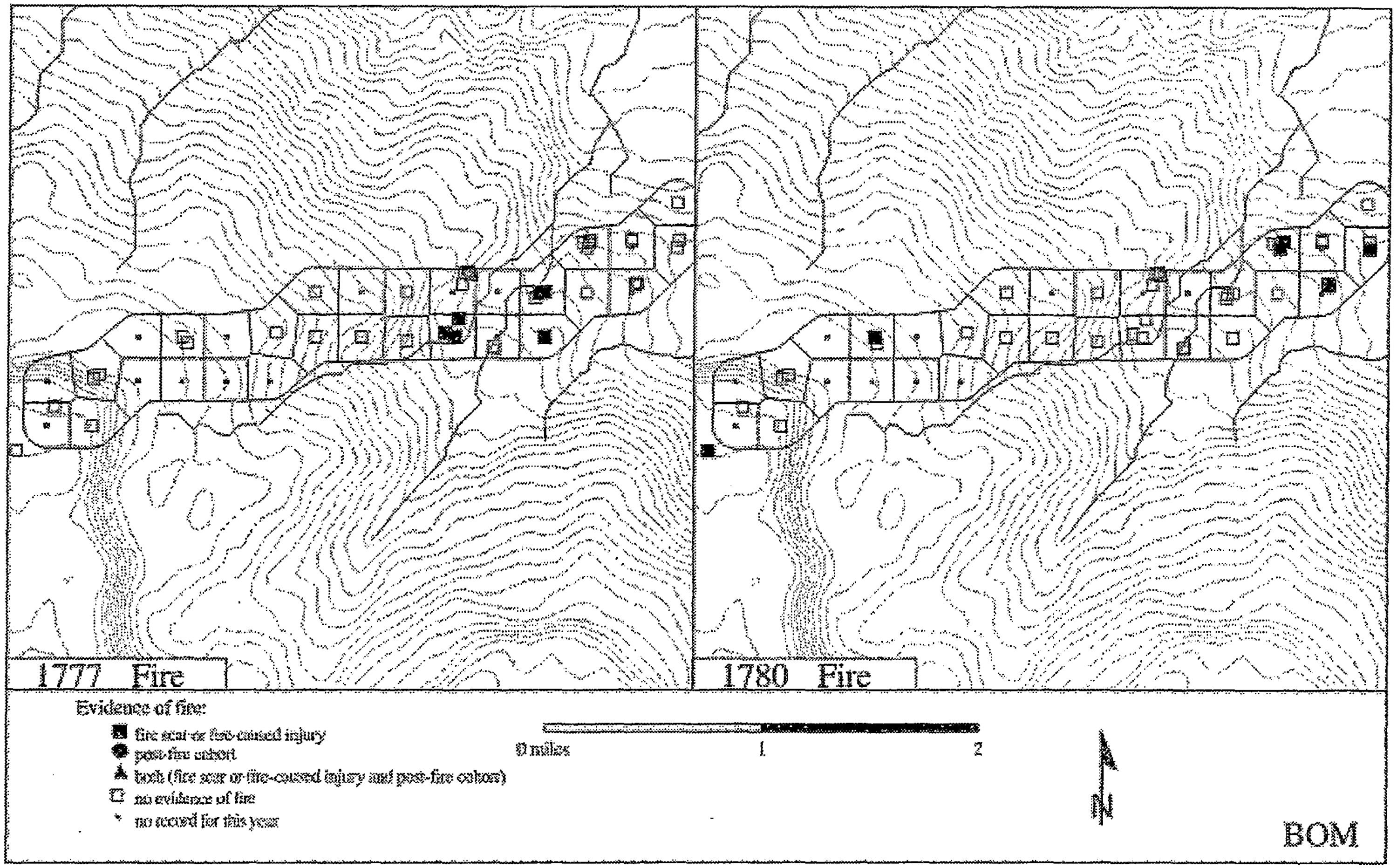

1728 Fire
1738 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

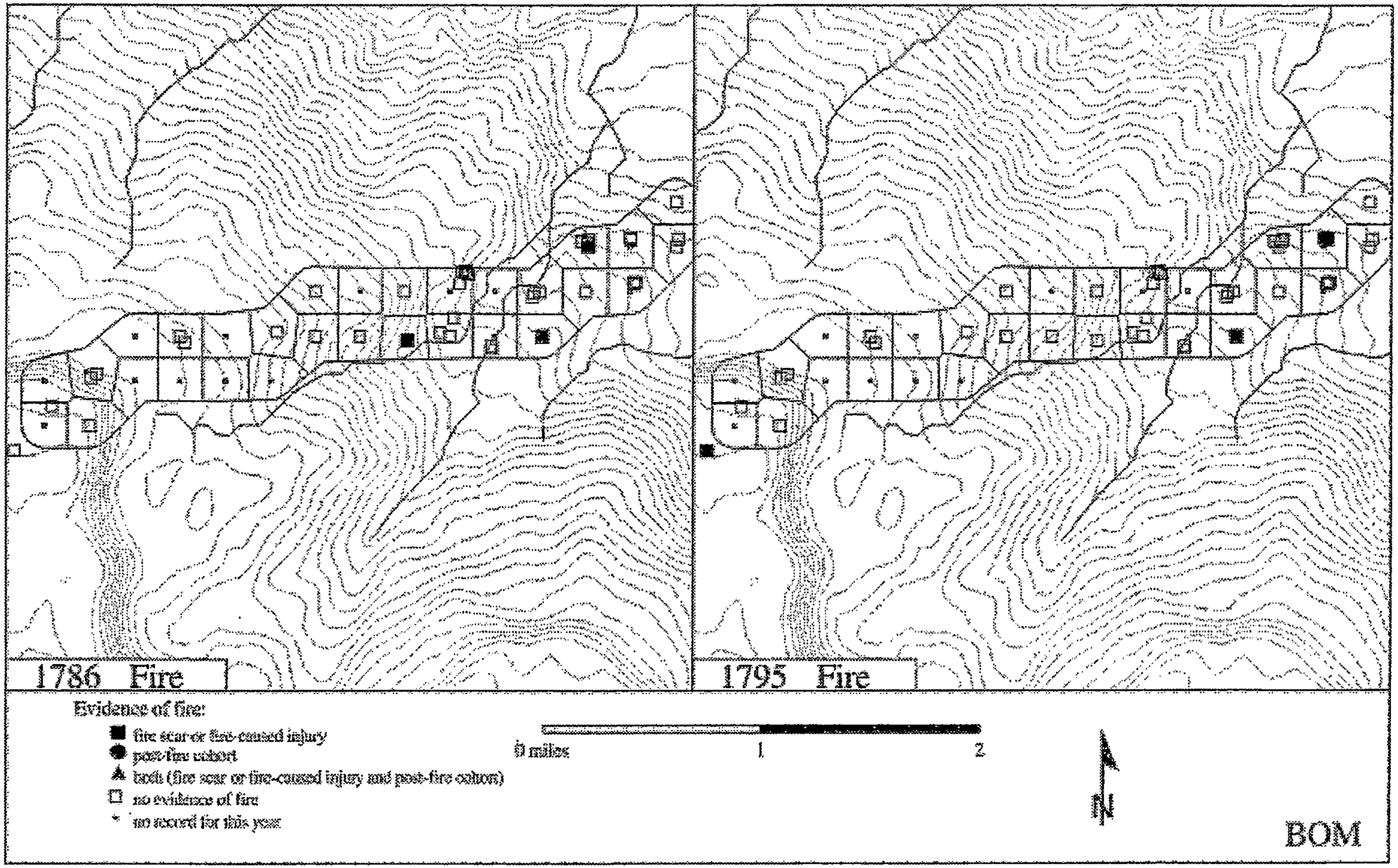

1745 Fire
1748 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

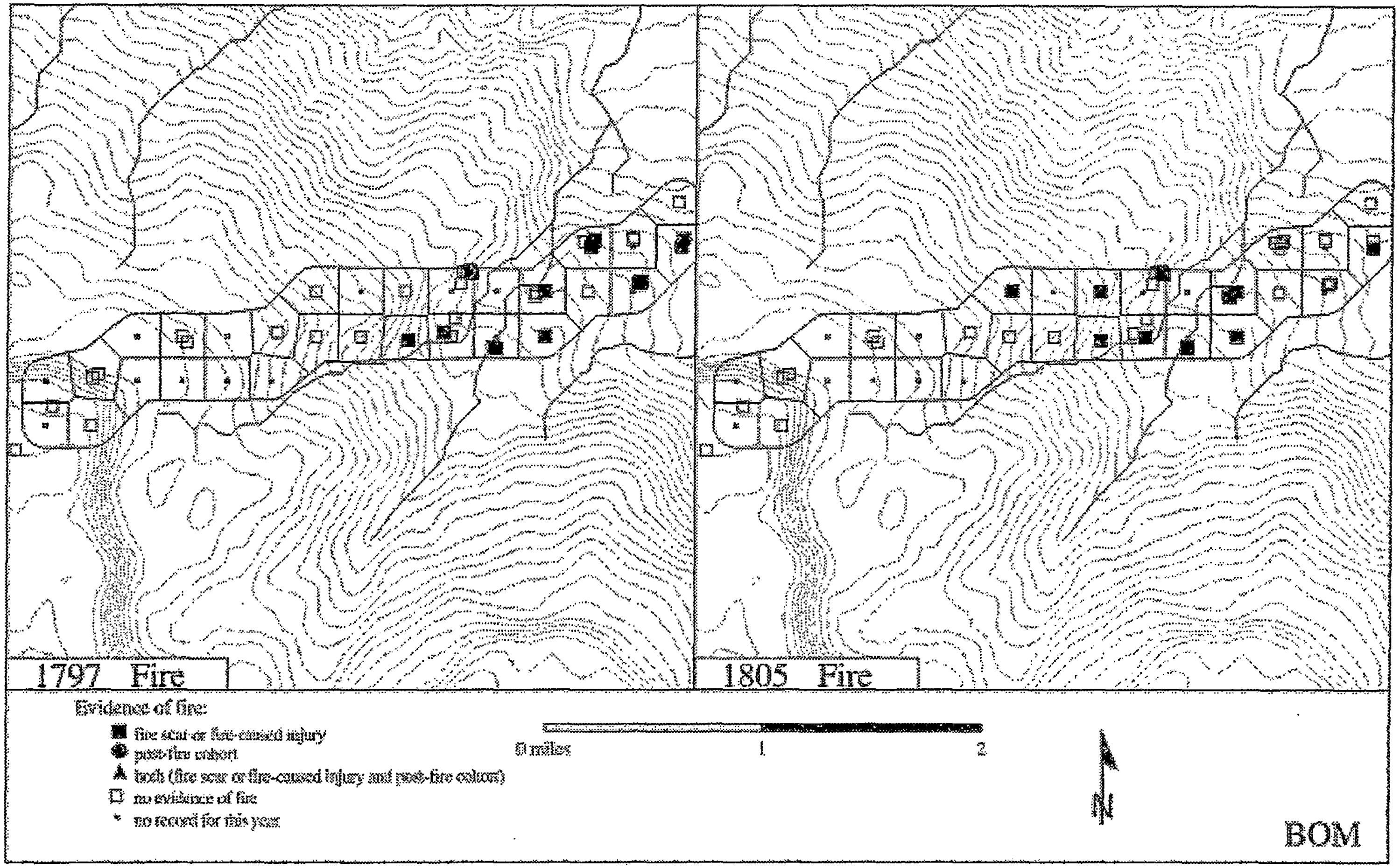

1750 Fire
1752 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

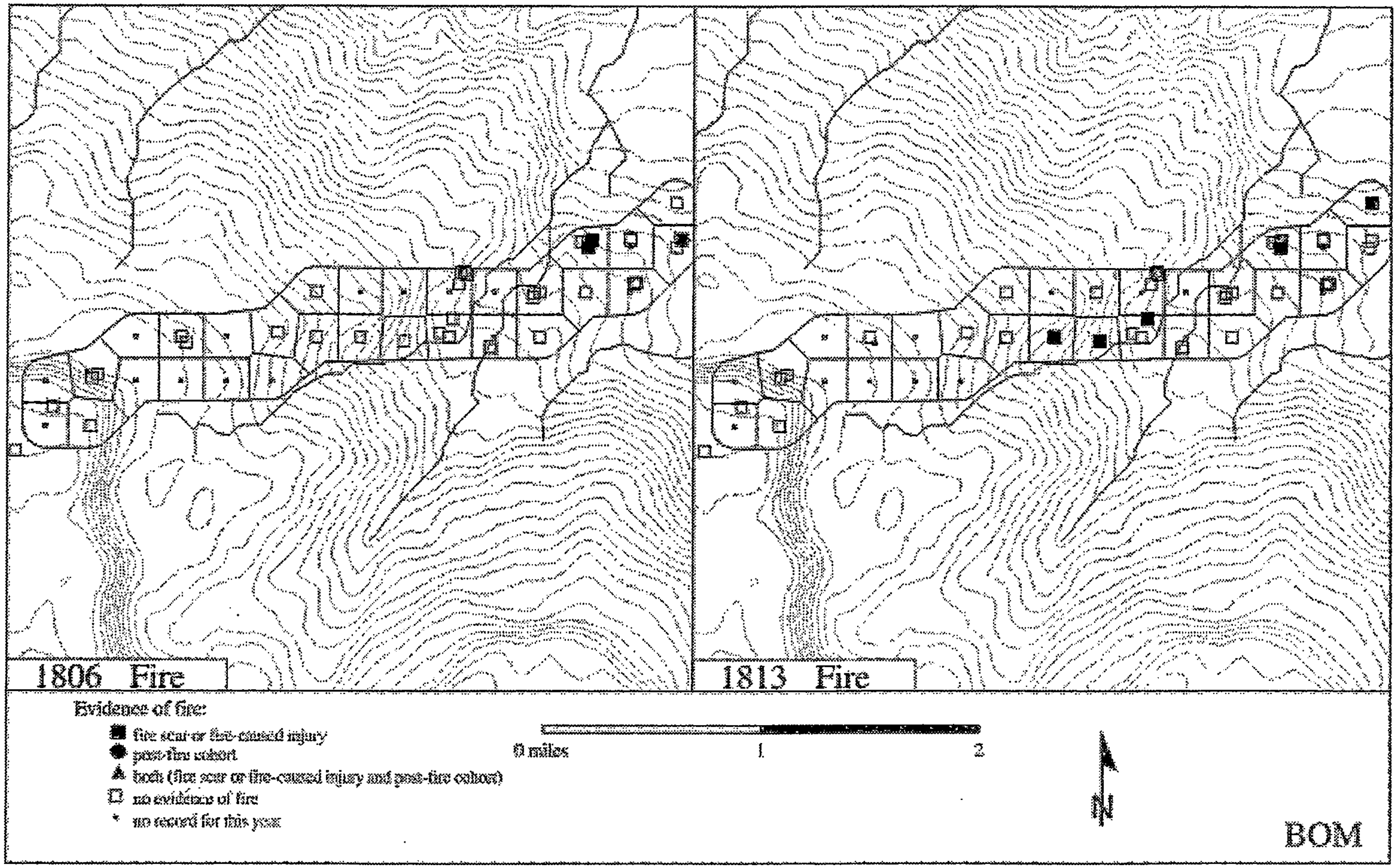

1762 Fire
1763 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

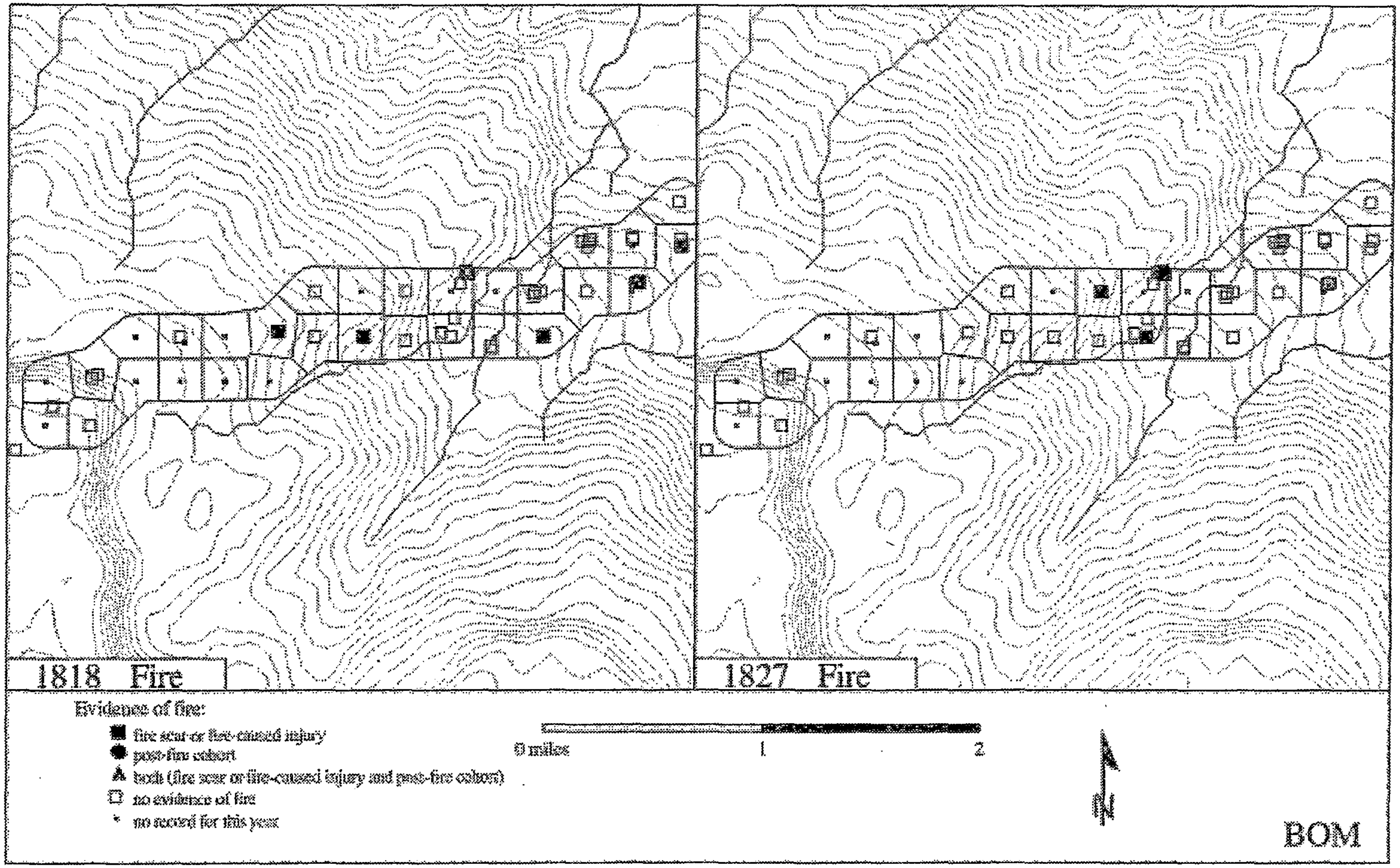

1765 Fire
1774 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

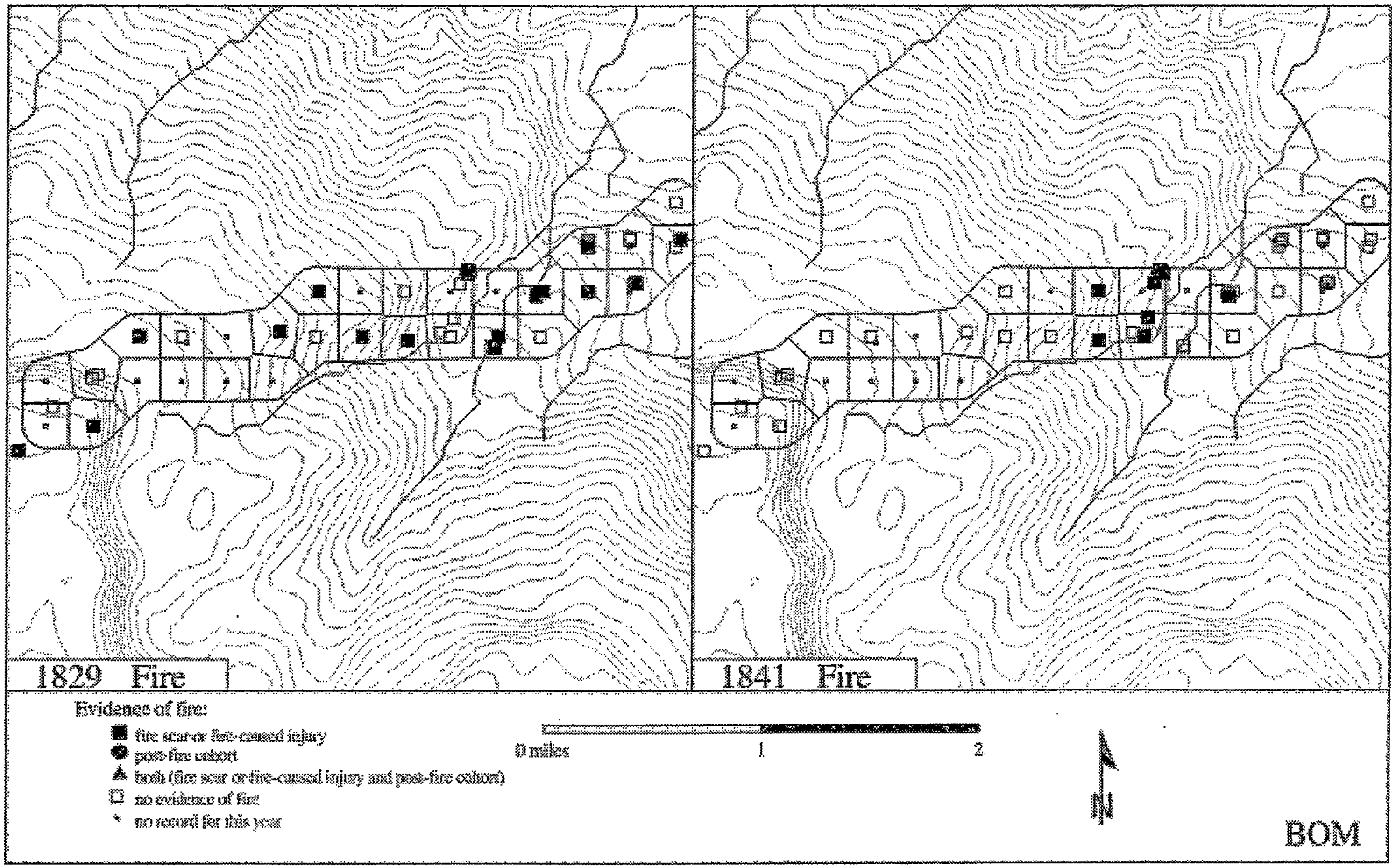

1777 Fire
1780 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

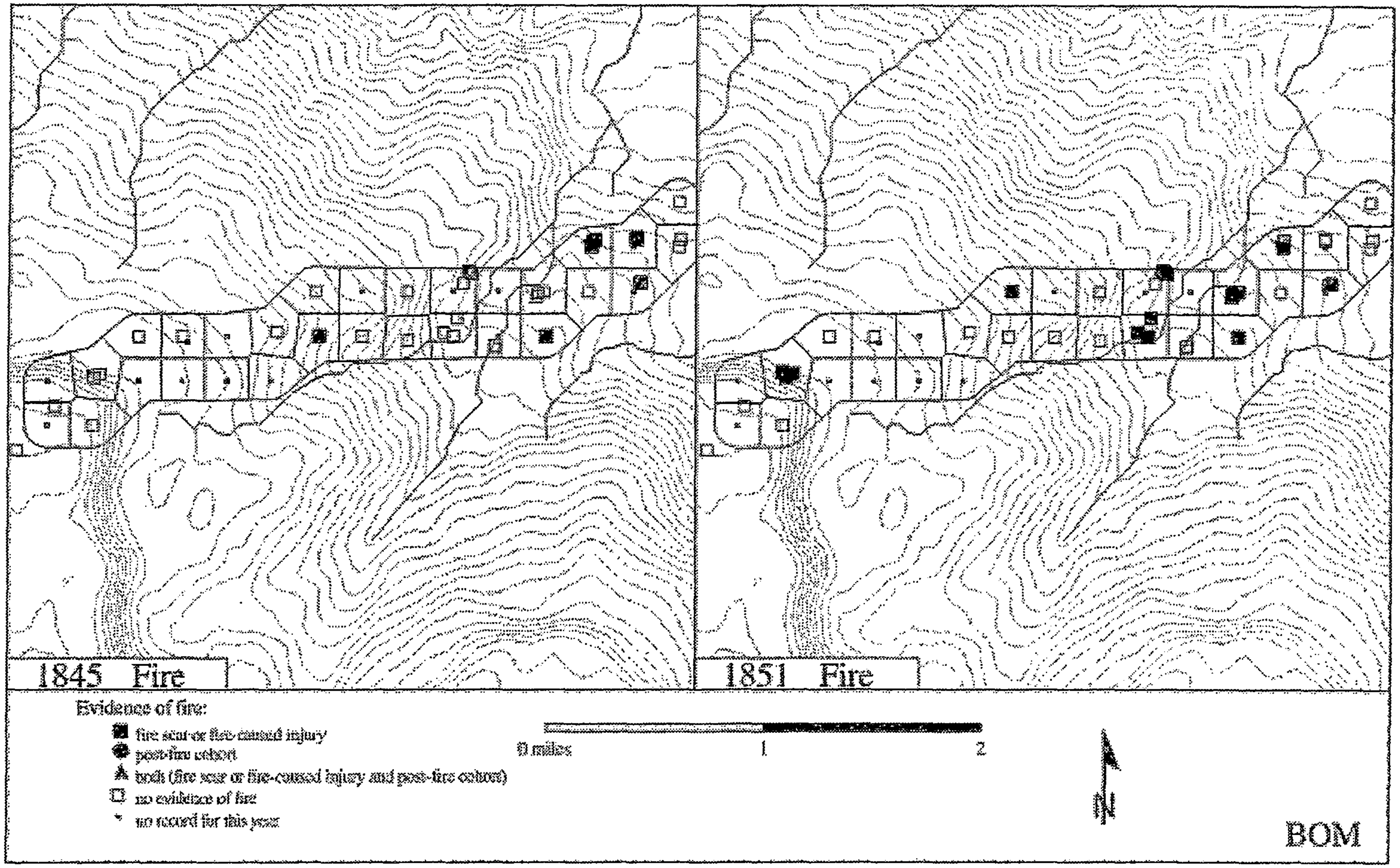

1786 Fire
1795 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

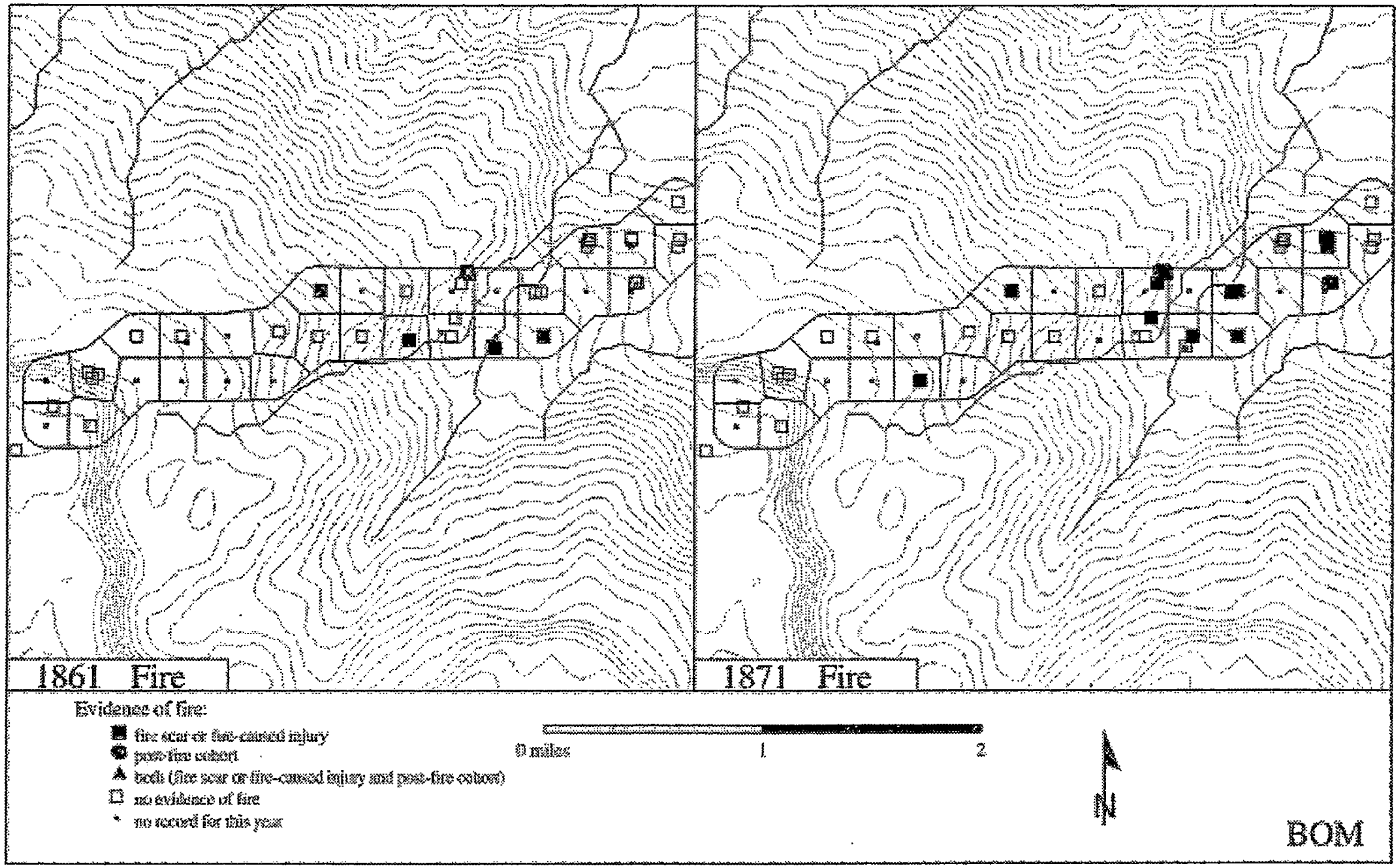

1797 Fire
1805 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM


1806 Fire
1813 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM


1818 Fire
1827 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM


1829 Fire
1841 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM


1845 Fire
1851 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM


1861 Fire
1871 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BOM

SNAKE RANGE - GREAT BASIN NATIONAL PARK (BMC)

Study Area

We sampled a grid of 24 plots over 1130 acres in upper Mill Creek, Great Basin National Park, in White Pine county, Nevada (Figure 111). The plots ranged in elevation from 7760 to 10600 ft, and slope from . Slope at the plots ranged from 19-57%. Almost all of the plots were sampled on north and east aspects (96%, Figure 112). The topography of the plots we sampled was generally similar to that of the sampling area at this site.

Results

Tree recruitment

Our plots included 674 total trees (79% live trees, with the rest stumps, logs and snags). Of these, we removed samples from 588 trees and were able to crossdate most of these (489 trees, or 83% of sampled trees). The trees that occurred on our plots included a range of species (Figure 113). Trees were recruited into the sampled plots between 1154 and 1963, although most trees (80%) were recruited after 1697 (Figure 114).

Average tree density was higher at plots in 2000 than in 1860 for all 8 of the forest types that we assigned to the sampled plots at this site (shrubland, sagebrush, mountain mahogany, pinyon-juniper, ponderosa, mixed conifer, aspen-mixed conifer, aspen, limber-bristlecone and spruce-fir, Figure 115, Table 2).

Surface fires

We removed fire-scarred sections from a total of 129 trees at BMC. We sampled most of these (79%) in the 16 of our 24 plots that contained such trees, and the remaining trees as we encountered them between plots. Of the total fire-scarred trees sampled, most were limber pine (36%), ponderosa pine (26%), Douglas-fir (12%) or white fir (9%), but we also sampled a few fire-scarred mountain mahogany, singleleaf pinyon, Great Basin bristlecone pine, quaking aspen and Engelmann spruce. Many of the trees we sampled were logs, snags or stumps (41%), with the rest live trees. We were unable to crossdate sections from some of the sampled trees (15%). Those that we did crossdate yielded 370 fire scars, and 59 eroded fire scars or abrupt changes in ring width (1003 to 2003; Figure 116). We were able to assign an intra-ring position to 78% of the fire scars. Most of the scars from the analysis period (1650-1900) were created by fires burning early in the cambial growing season or when the cambium was dormant, although the distribution of scars by intra-ring position varied among species at this site (73% of assigned scars, Figure 117).

The number of surface fires during the analysis period (1650-1900) varied with elevation and forest type at BMC (Figure 118), with fires most frequent at mid elevations, and in the mixed-conifer forest type. Surface fires ceased in the late 1800s at this site (Figure 116).

Figures and tables for BMC

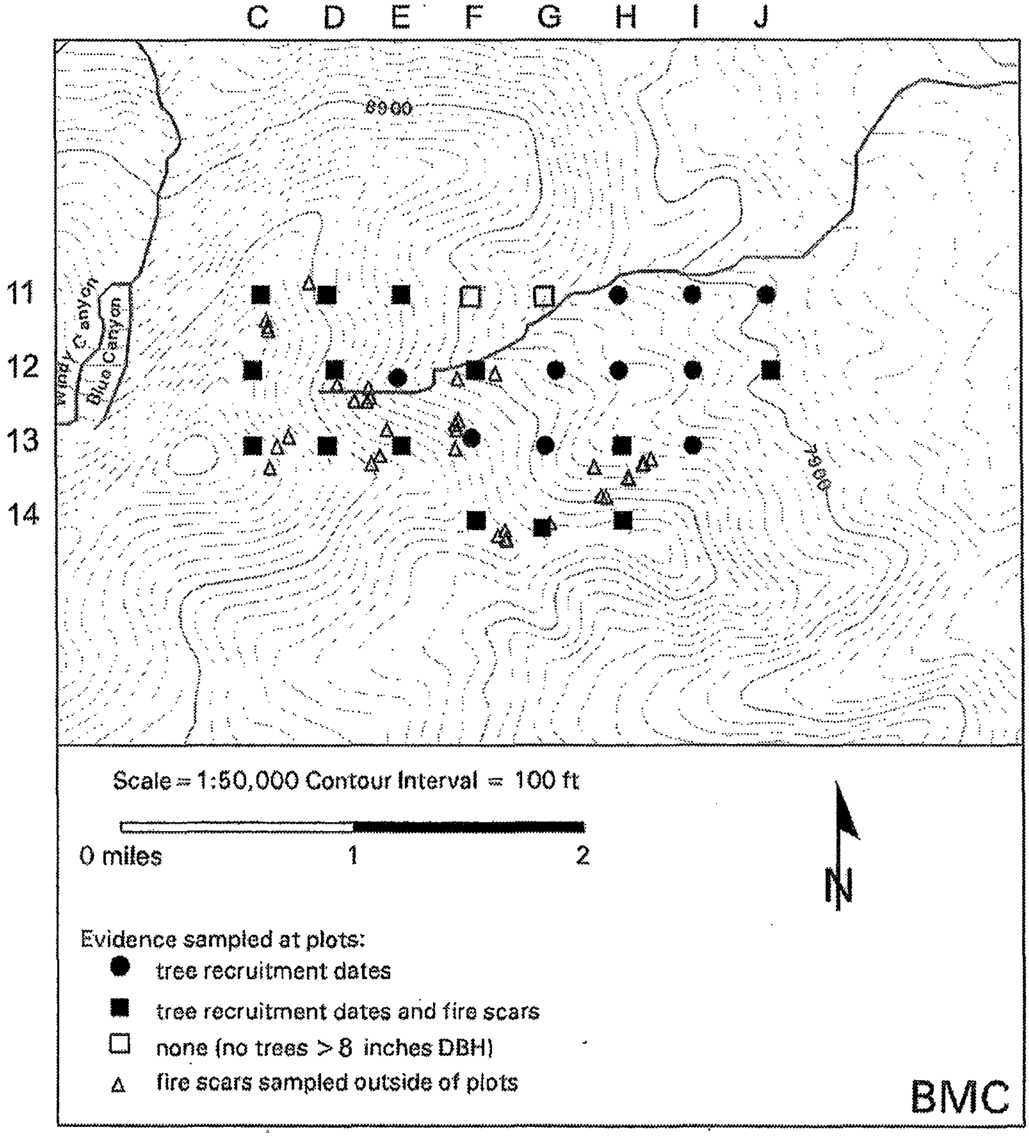


Figure 111. Location of plots and fire-scarred trees sampled outside plots. Plots are identified by column and row, i.e., the northwestern most plot is 11C, the next plot to the east is 11D, etc. Most of the fire-scarred trees (79% of 110 dated trees) were sampled within plots and so are not mapped individually.

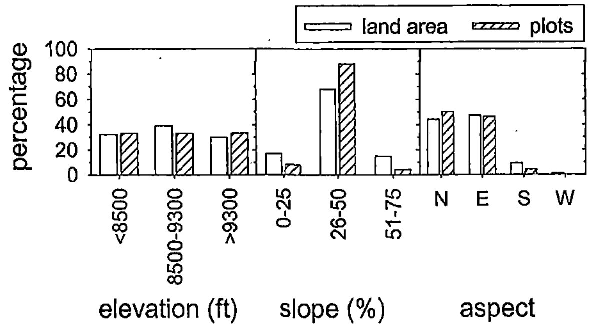


Figure 112. Distribution of topography for sampled plots and for land area at BMC. Aspect classes are 90° wide, beginning with 46° for east (E). Land area was derived from a digital elevation model.

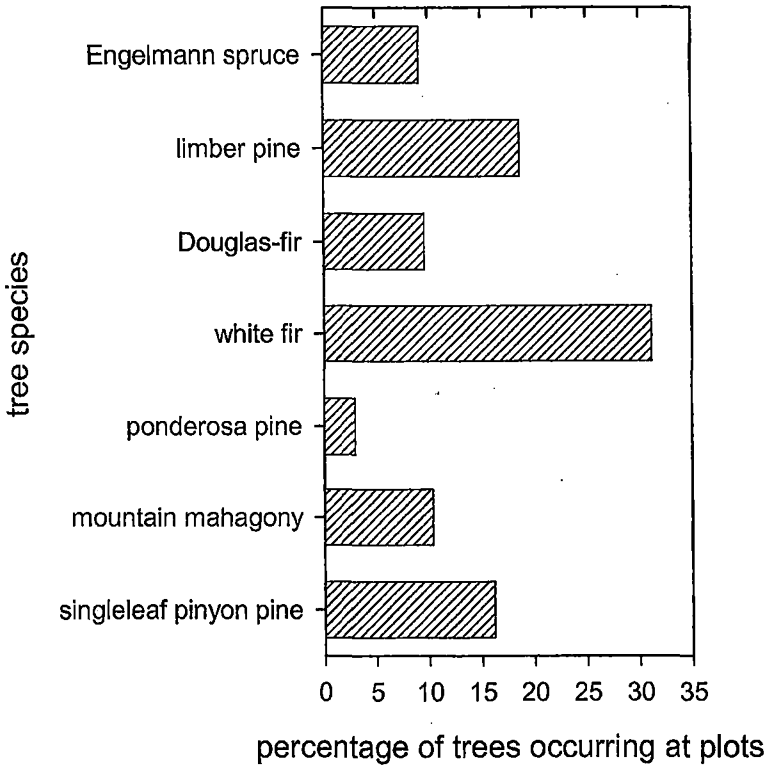


Figure 113. Species distribution of all trees that occurred in plots at BMC. In addition, 4 quaking aspen, 2 Utah juniper and 2 Great Basin bristlecone pine trees occurred in our plots but are not shown.

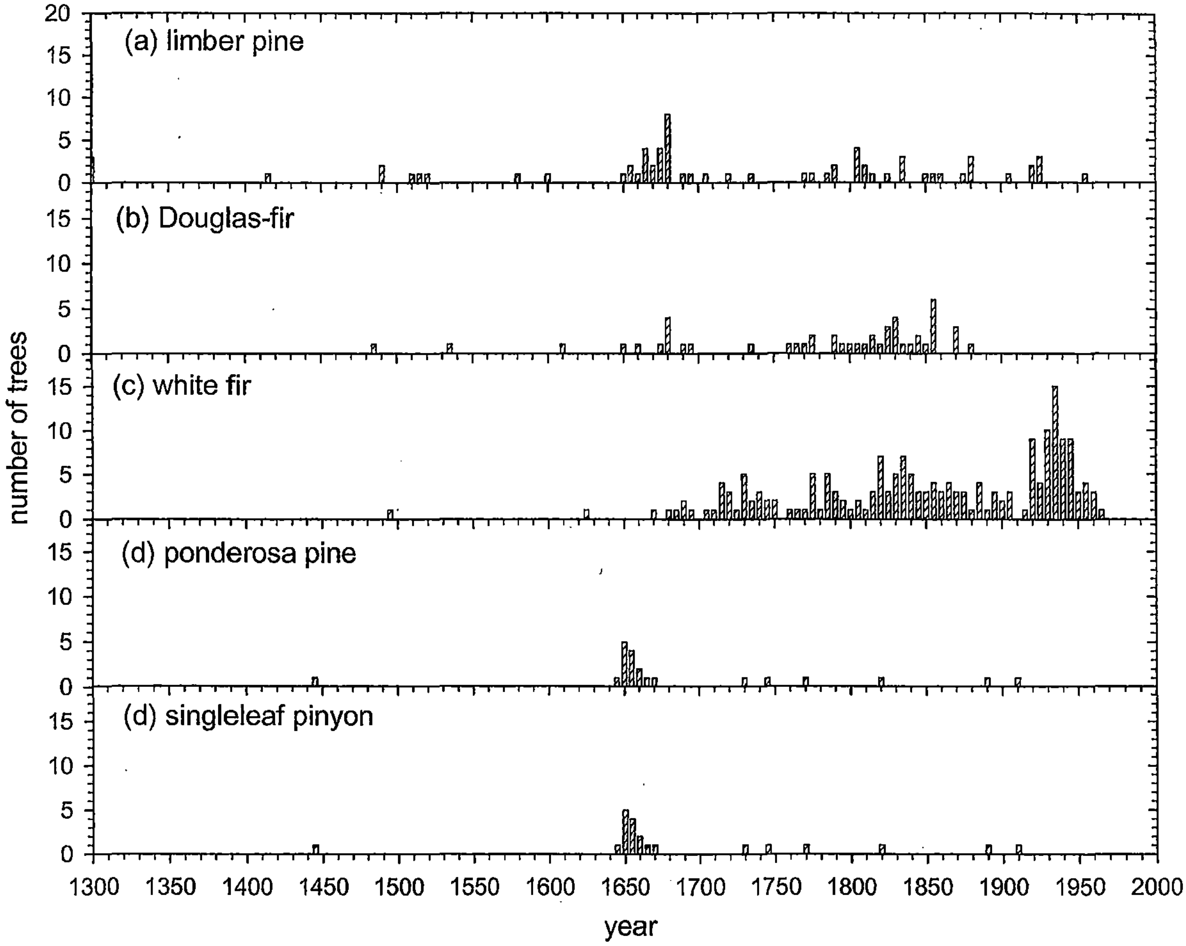


Figure 114. Distribution of tree-recruitment dates by species at BMC, for all species comprising >10% of dated trees. We only cored trees >8 inches DBH, so the later part of the distributions are incomplete, and the degree of incompleteness differs among sites because cambial growth varies among sites.

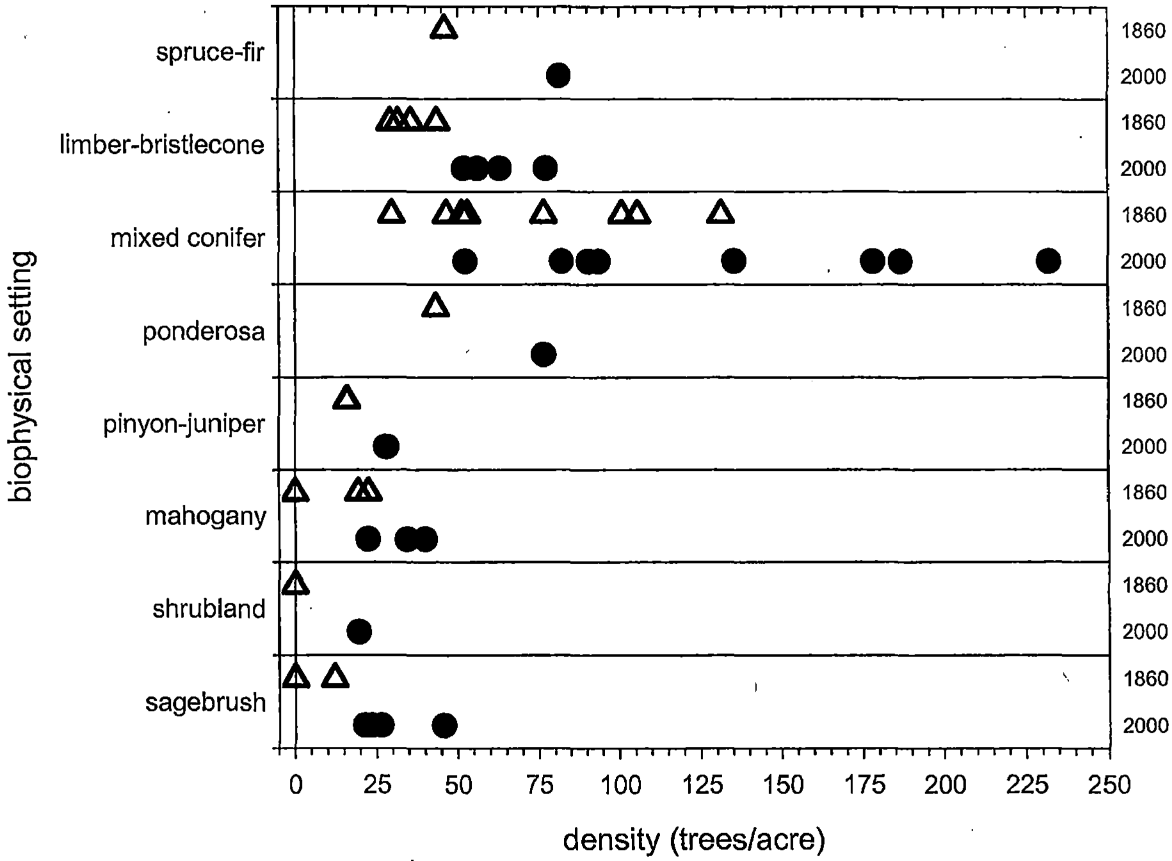


Figure 115. Density of live trees >8 inches DBH at each plot at BMC, in 1860 (open triangles) and 2000 (solid circles), by forest type (Table 2).

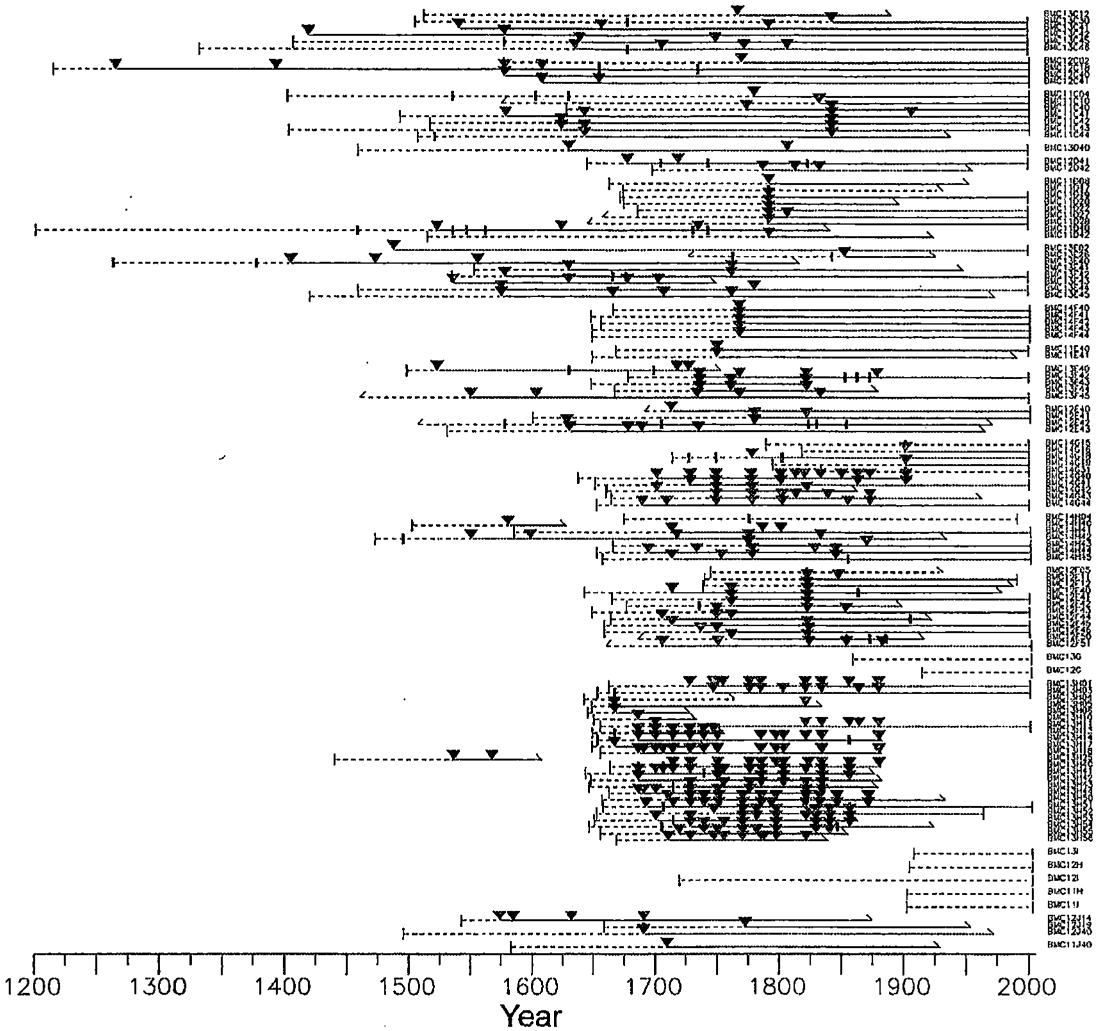


Figure 116. Fire chronologies at BMC, grouped by cell, from high (top) to low (bottom) elevation (Grissino-Mayer 1995). Horizontal lines show the record for an individual tree, with fire-scar dates marked by triangles. Recorder years (solid portions of the lines) generally follow the first fire-scar on that tree. Non-recorder years (dashed lines) precede the formation of the first scar on each tree but may also occur after the first scar when a period of the fire record was consumed by subsequent fires or rot. Inside dates on each tree are marked by a short vertical line for piths or short slanted lines for inside dates (with an unknown number of rings to pith), while outer dates are marked by short vertical lines for bark or slanted line for outside date (unknown number of rings to bark and tree death date). For cells that contained no sampled fire-scarred trees, a dashed line indicates the time span covered by the oldest tree collected from the plot in that cell.

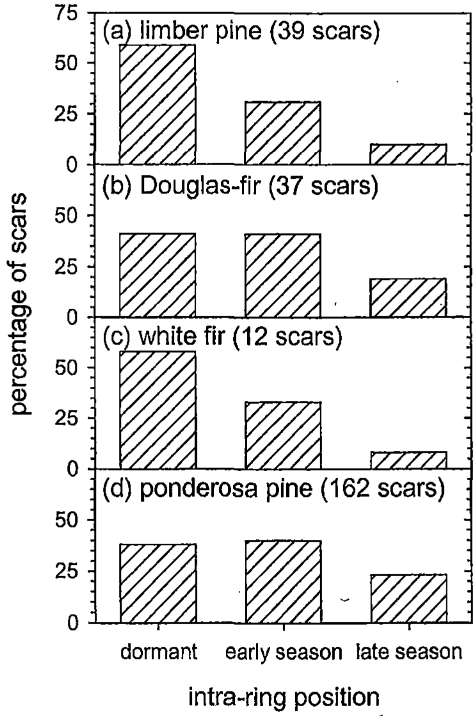


Figure 117. Intra-ring position of fire scars at BMC (1650-1900), by tree species, for scars for which we could determine a season. Number of scars is given in parentheses. Dormant-season scars were formed by fires that burned between cambial growing seasons, whereas early- and late-season scars were formed by fires that burned during the cambial growing season (early-earlywood plus middle-earlywood and late-earlywood plus latewood scars, respectively). Only species that comprised >10% of trees are plotted. We also dated scars from some Engelmann spruce, Great Basin bristlecone pine and singleleaf pinyon, but these species yielded too few scars with an intra-ring position to plot here.

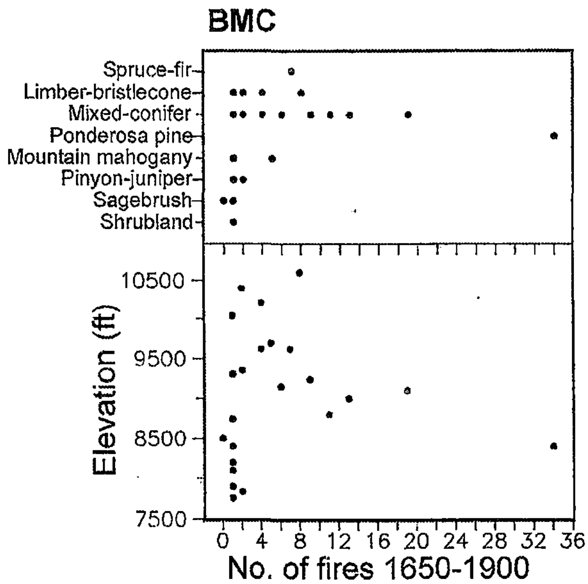
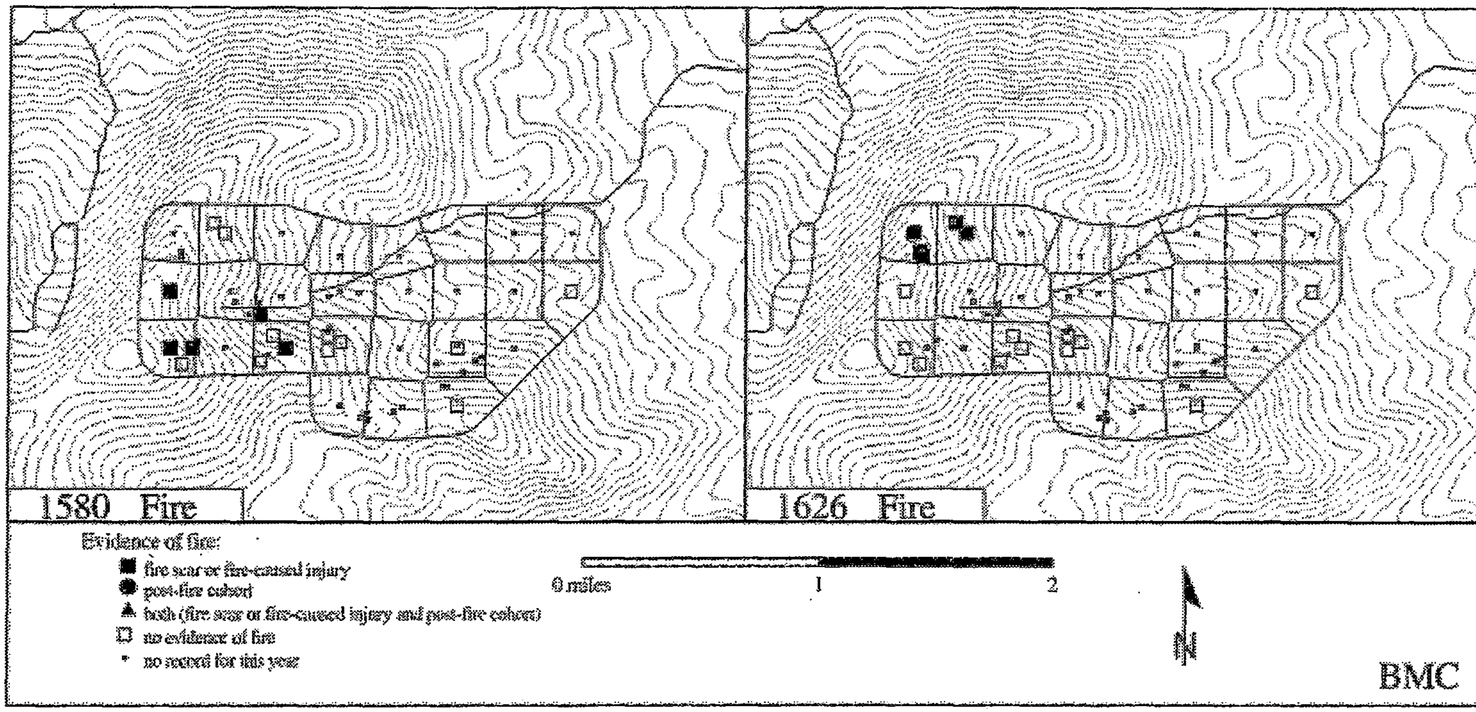
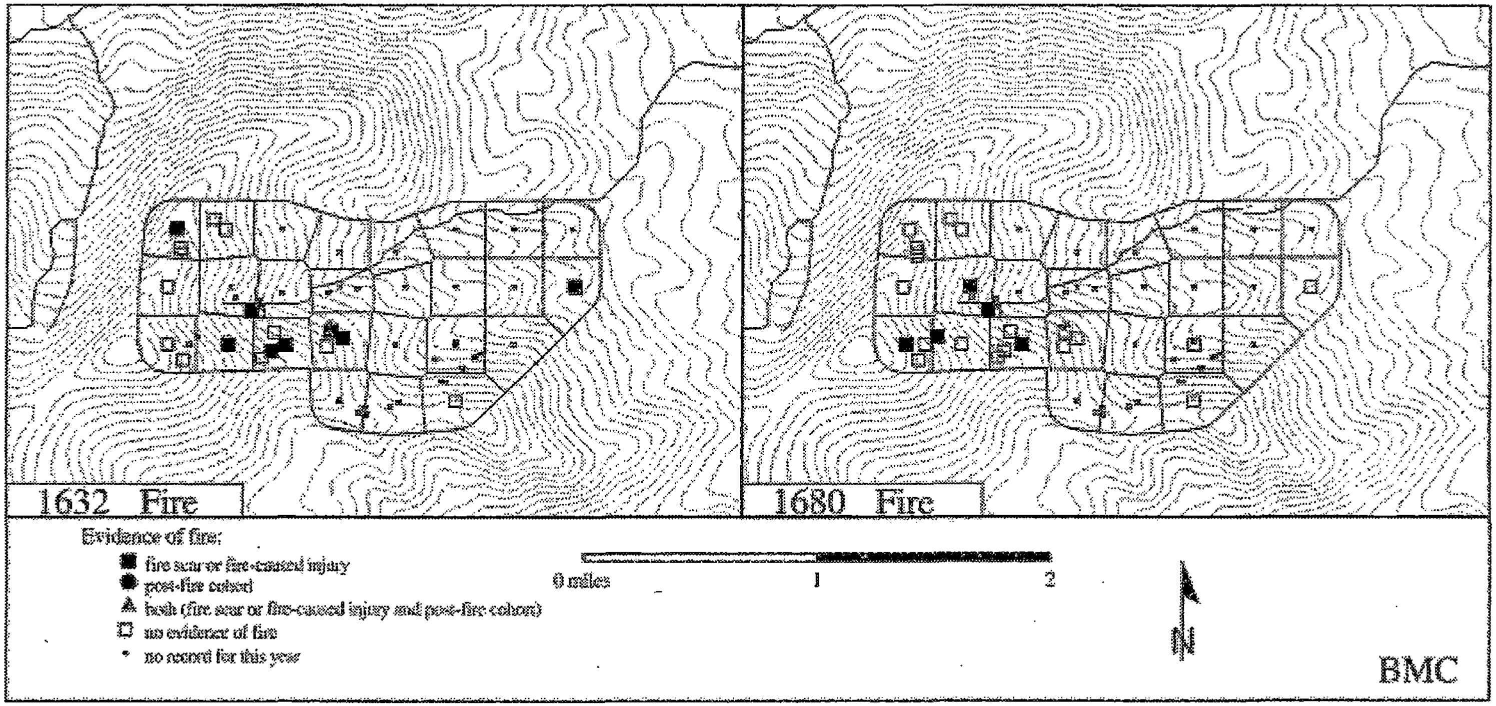


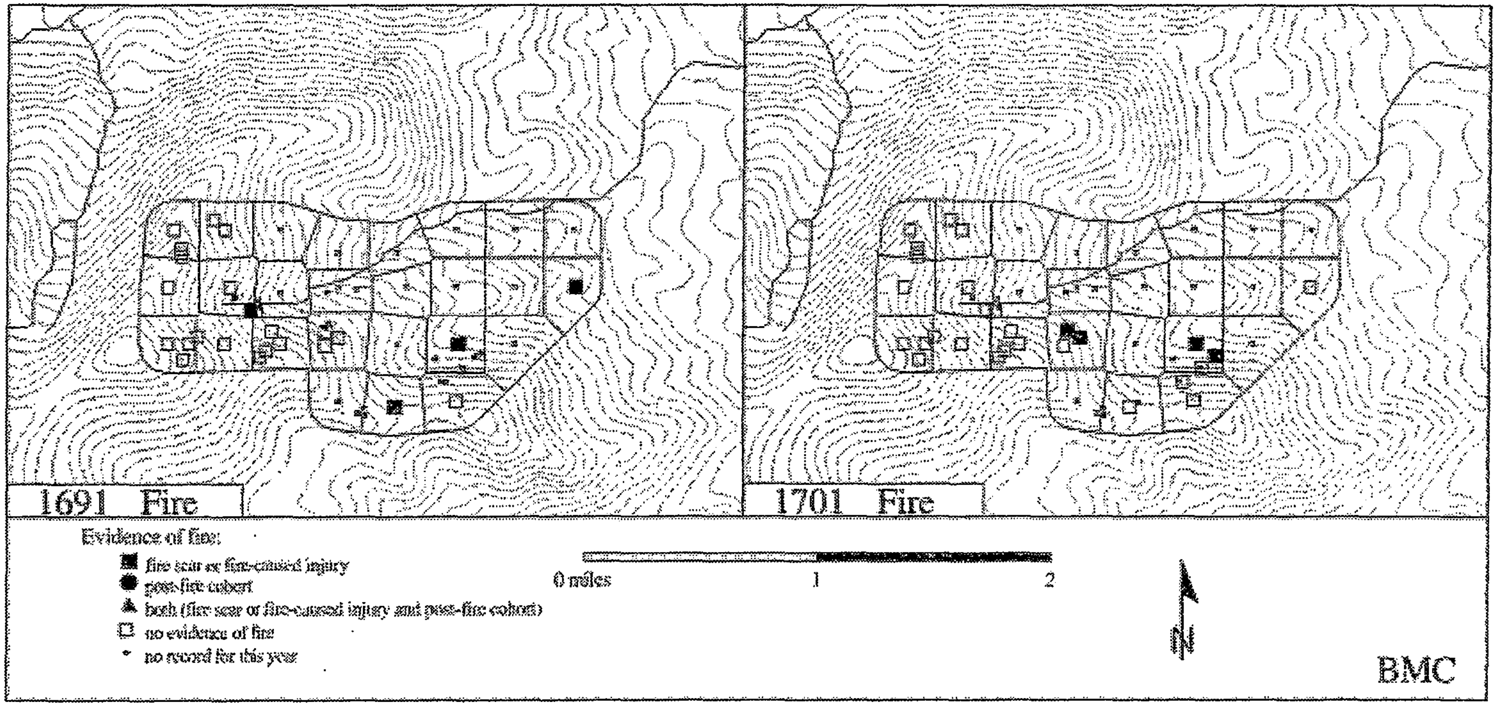
Figure 118. Number of fires within cells at BMC (1650-1900), by forest type (top panel, Table 2) and elevation (bottom panel). Number of fires includes only those fire years which were recorded on ≥2 trees at a site.

Maps of surface fires at BMC

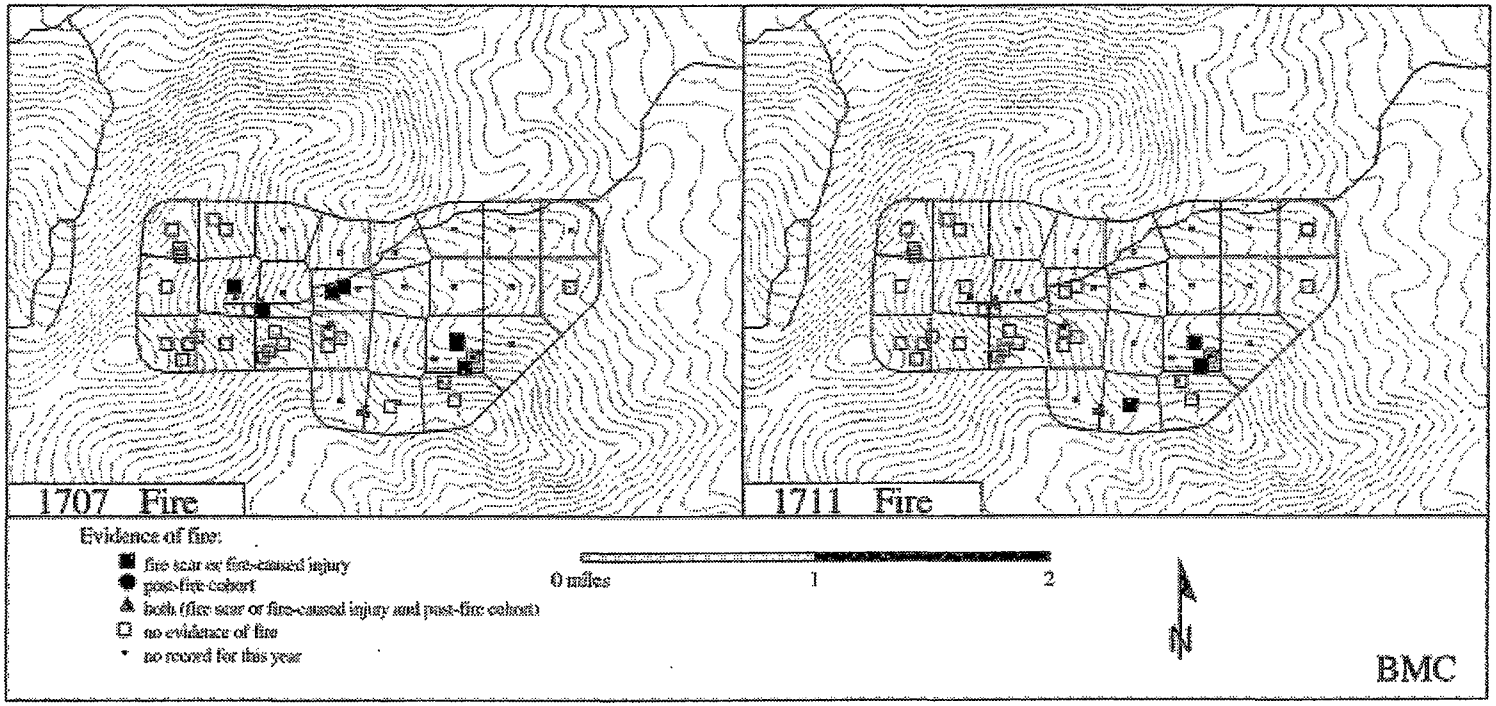
The following maps show evidence of surface fires only for those years during which 4 or more locations (i.e., plots or fire-scarred trees sampled outside of plots) had evidence of fire. Each point on the maps represents either a composite of fire events within ≈260 feet of a plot, or a tree that was sampled outside of the plots. We have not yet identified post-fire cohorts from the tree recruitment dates so, while a symbol for this appears in the legend, no such symbols appear on the maps. No evidence of fire indicates that live trees existed at that location during that year but did not record evidence of fire. In contrast, no record for this year indicates that no trees were alive at that location during that year. We consider these plots to be unsampled.

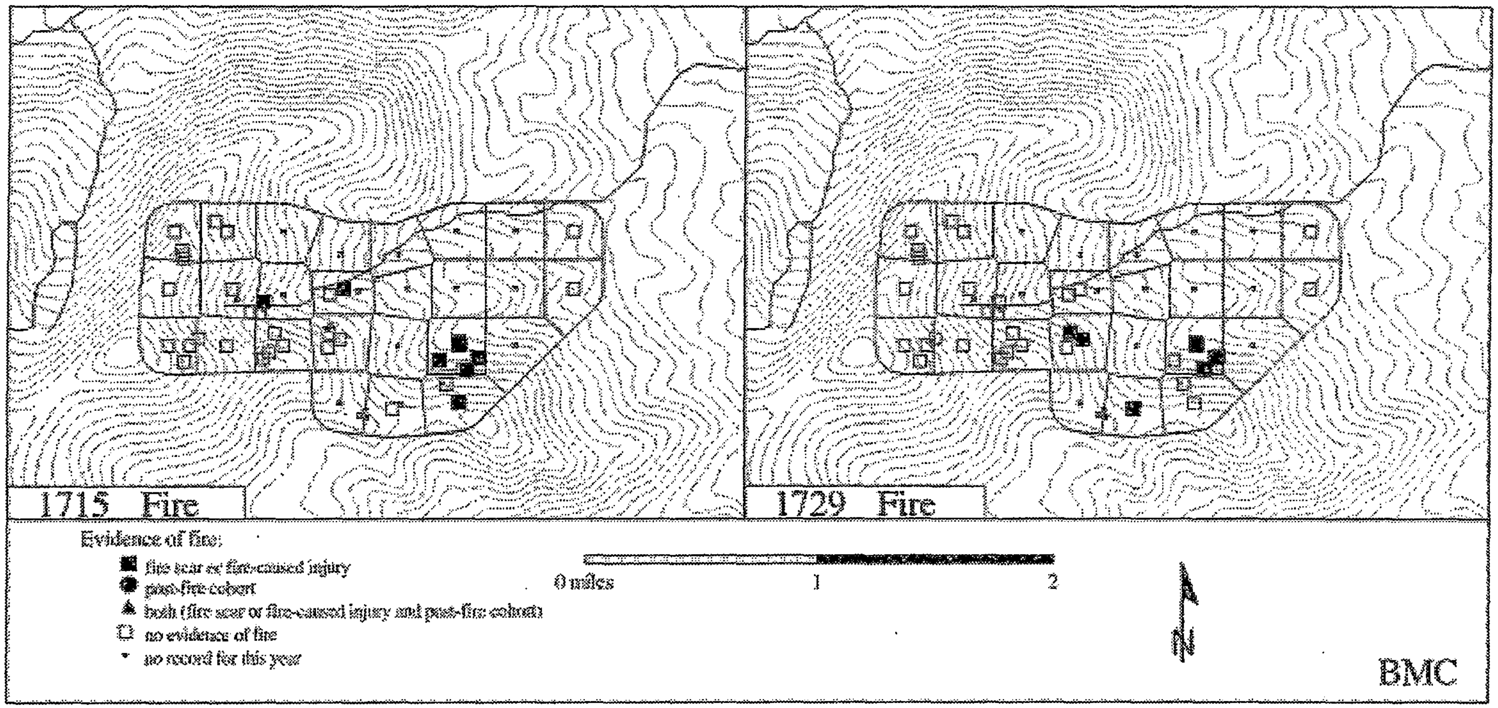

1580 Fire
1626 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC

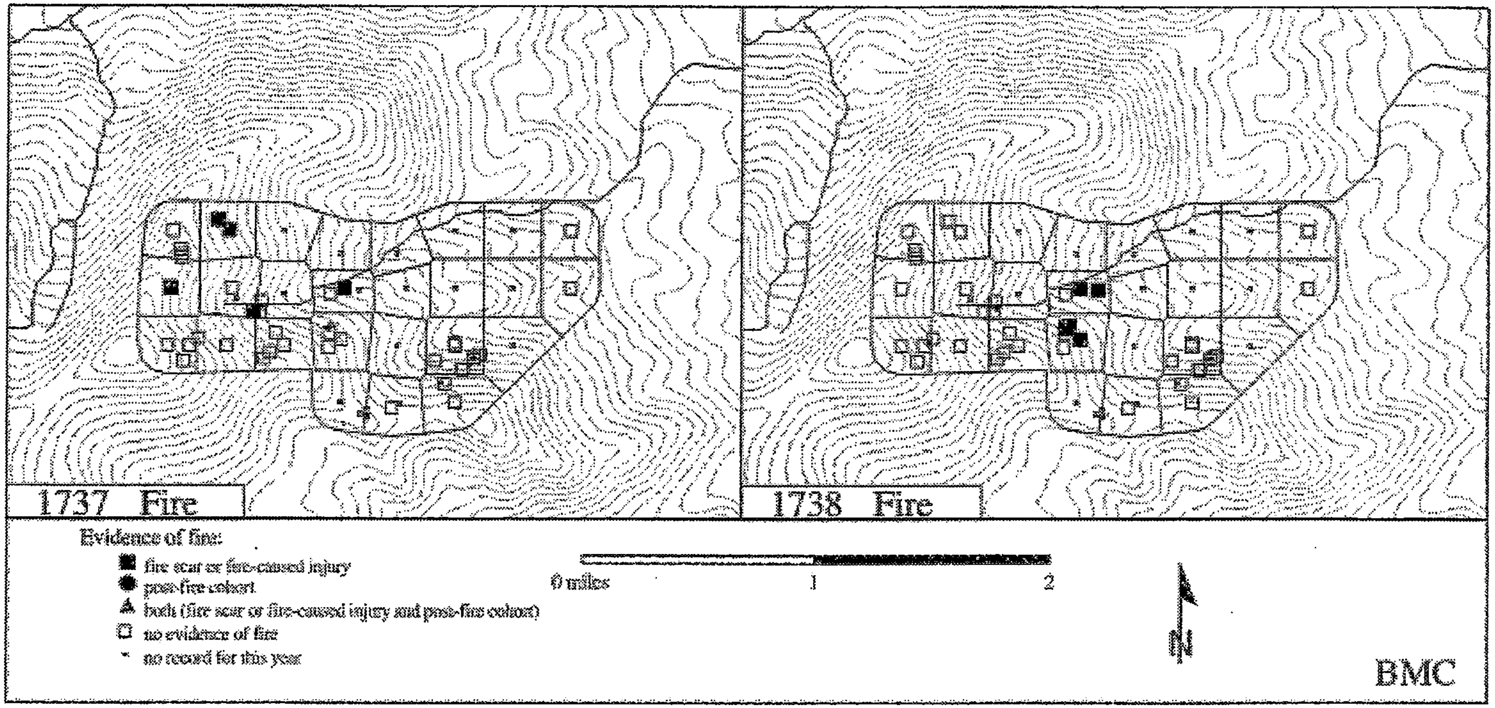

1632 Fire
1680 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC

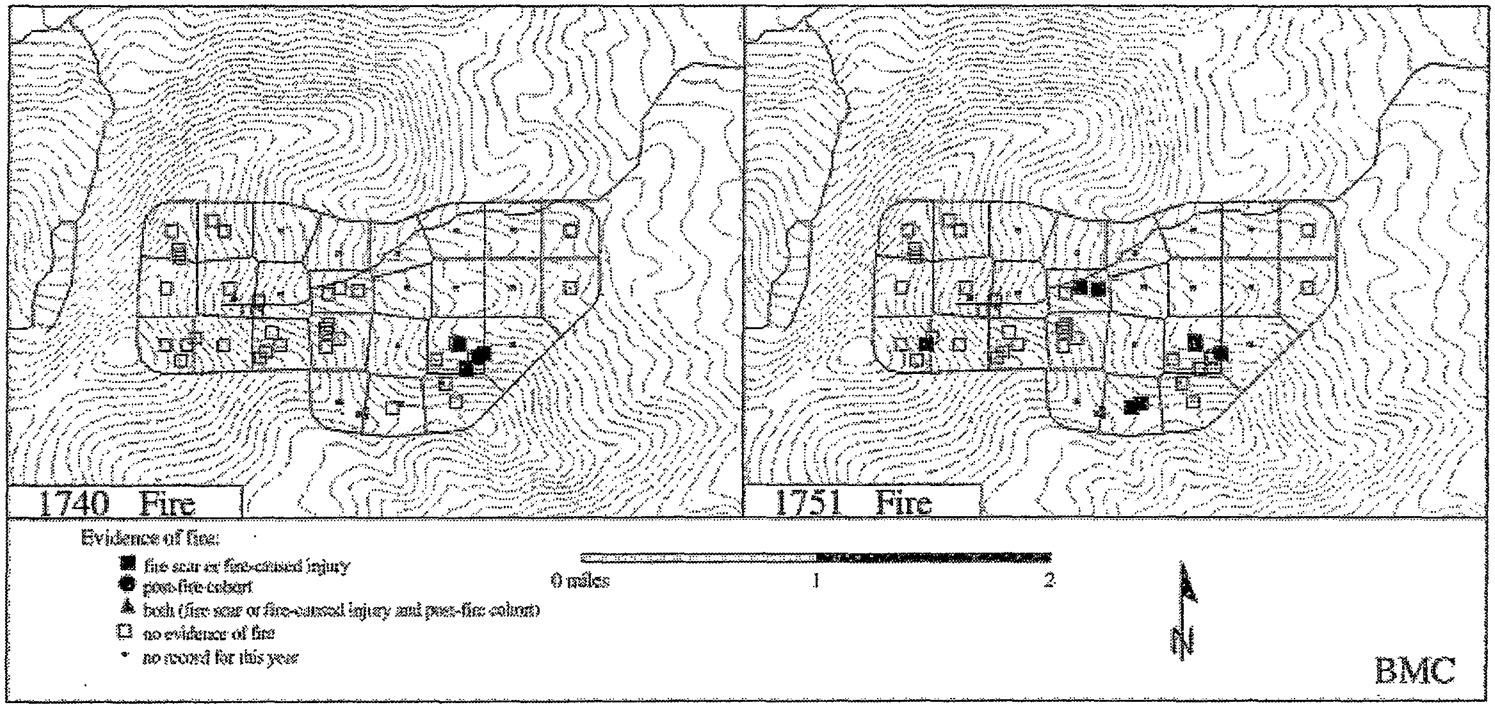


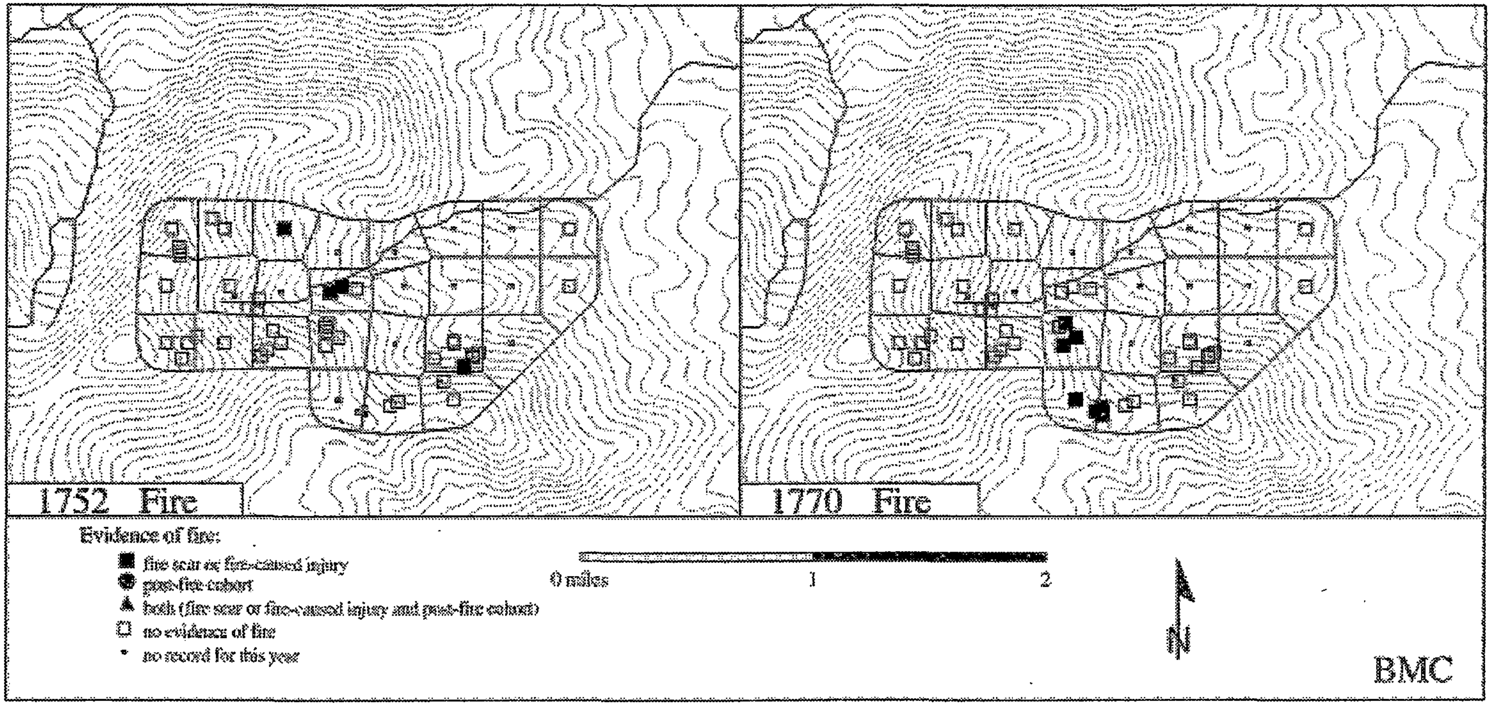
1691 Fire
1701 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC


1707 Fire
1711 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC


1715 Fire
1729 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC


1737 Fire
1738 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC


1740 Fire
1751 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC


1752 Fire
1770 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
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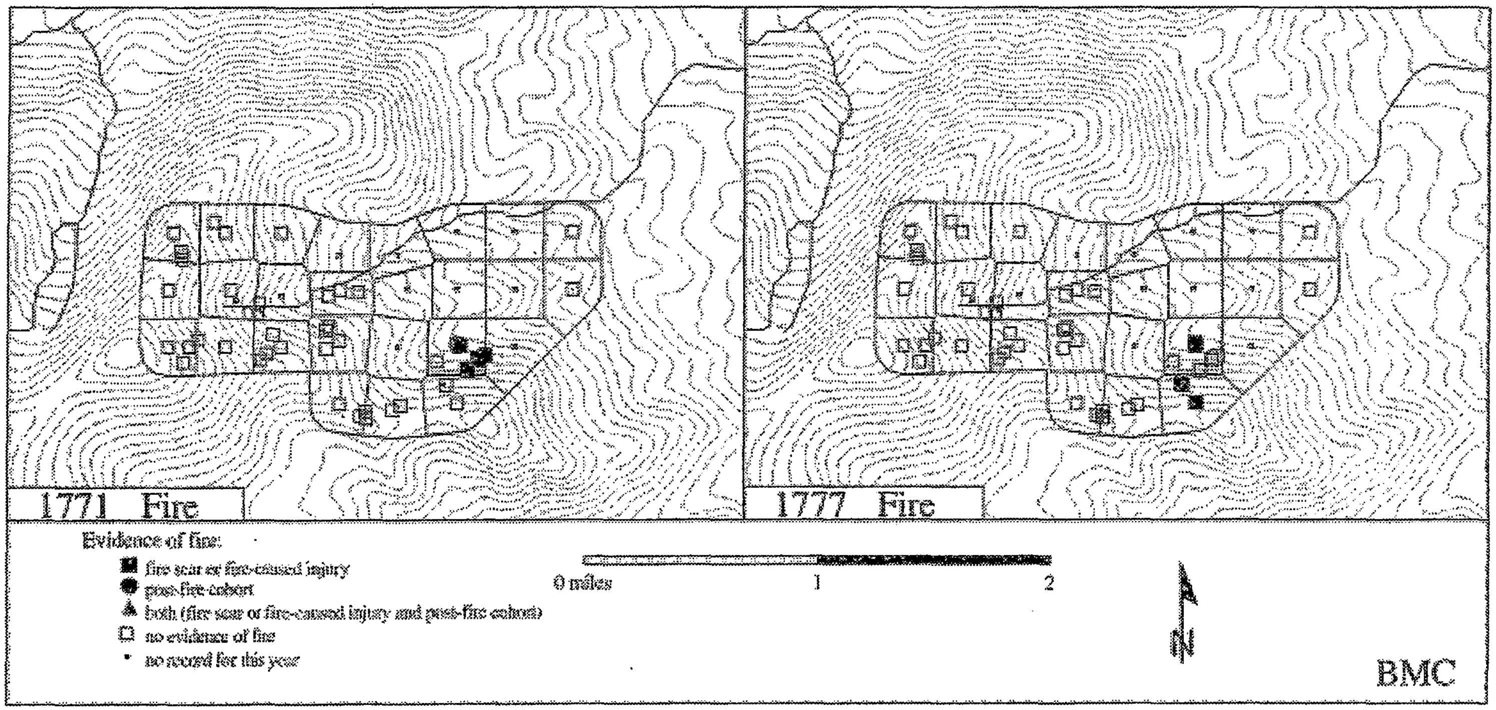
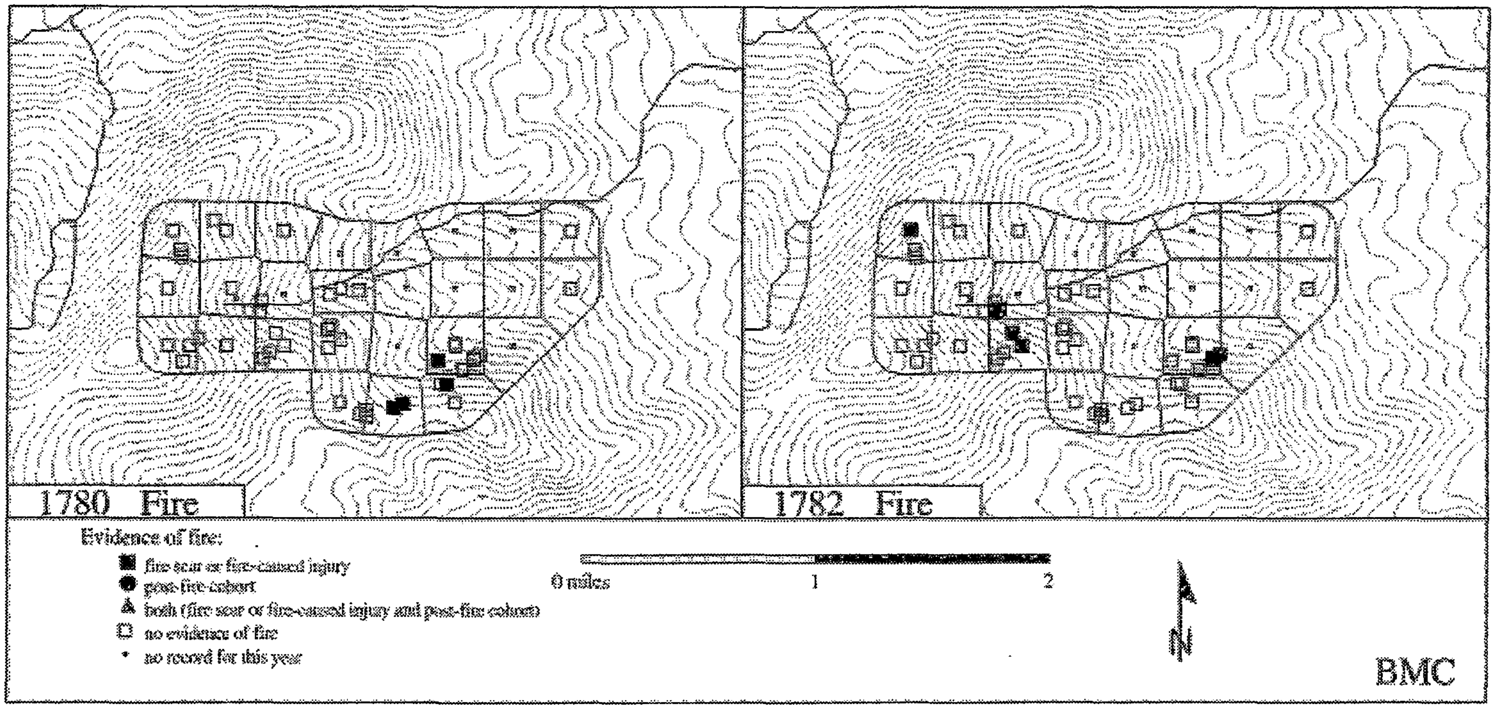
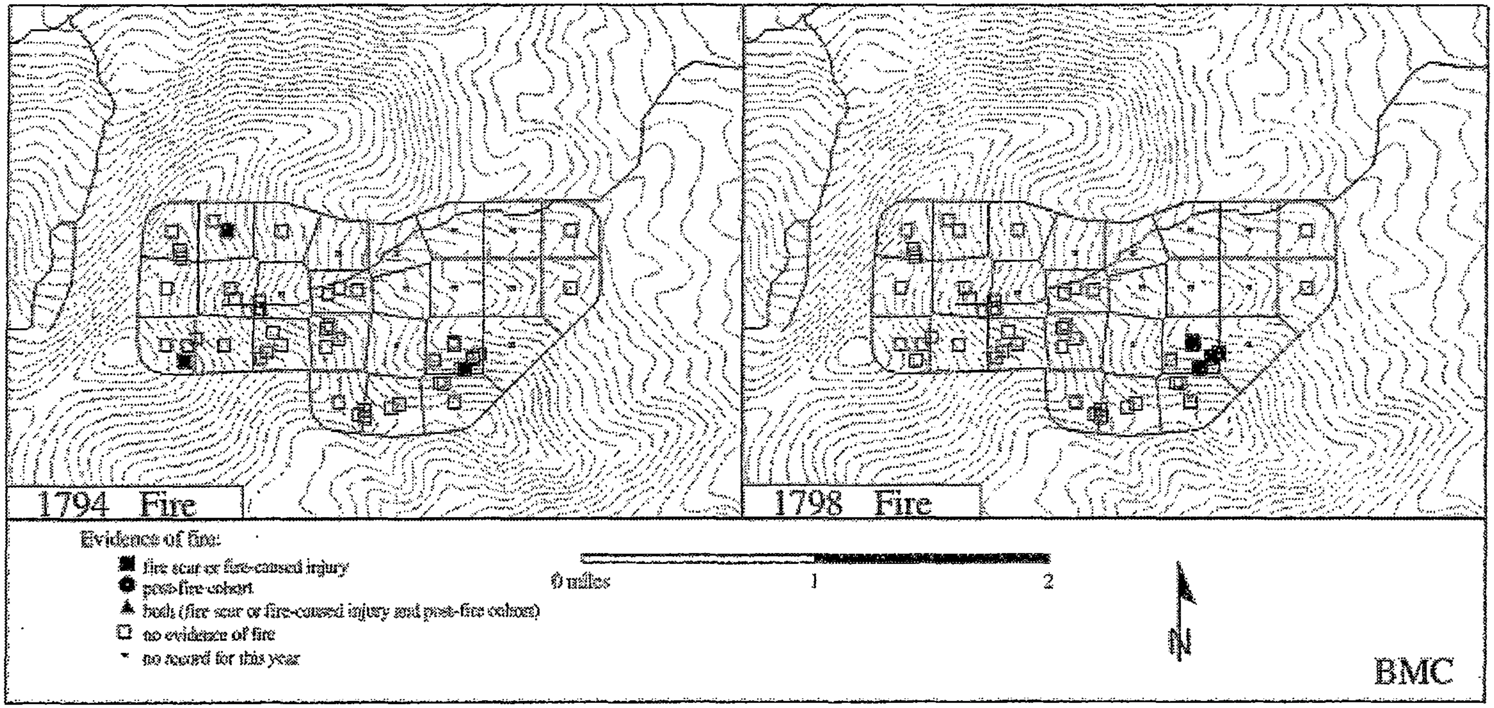
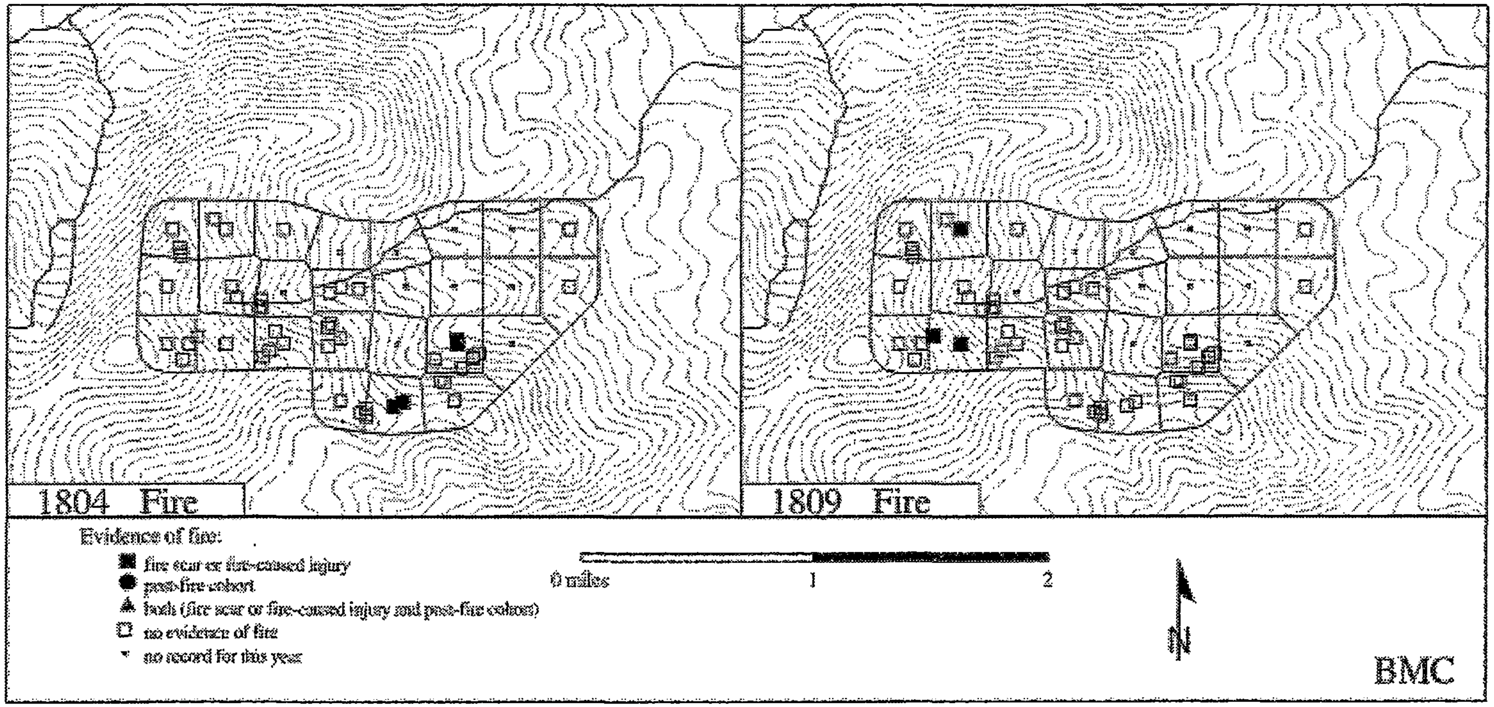
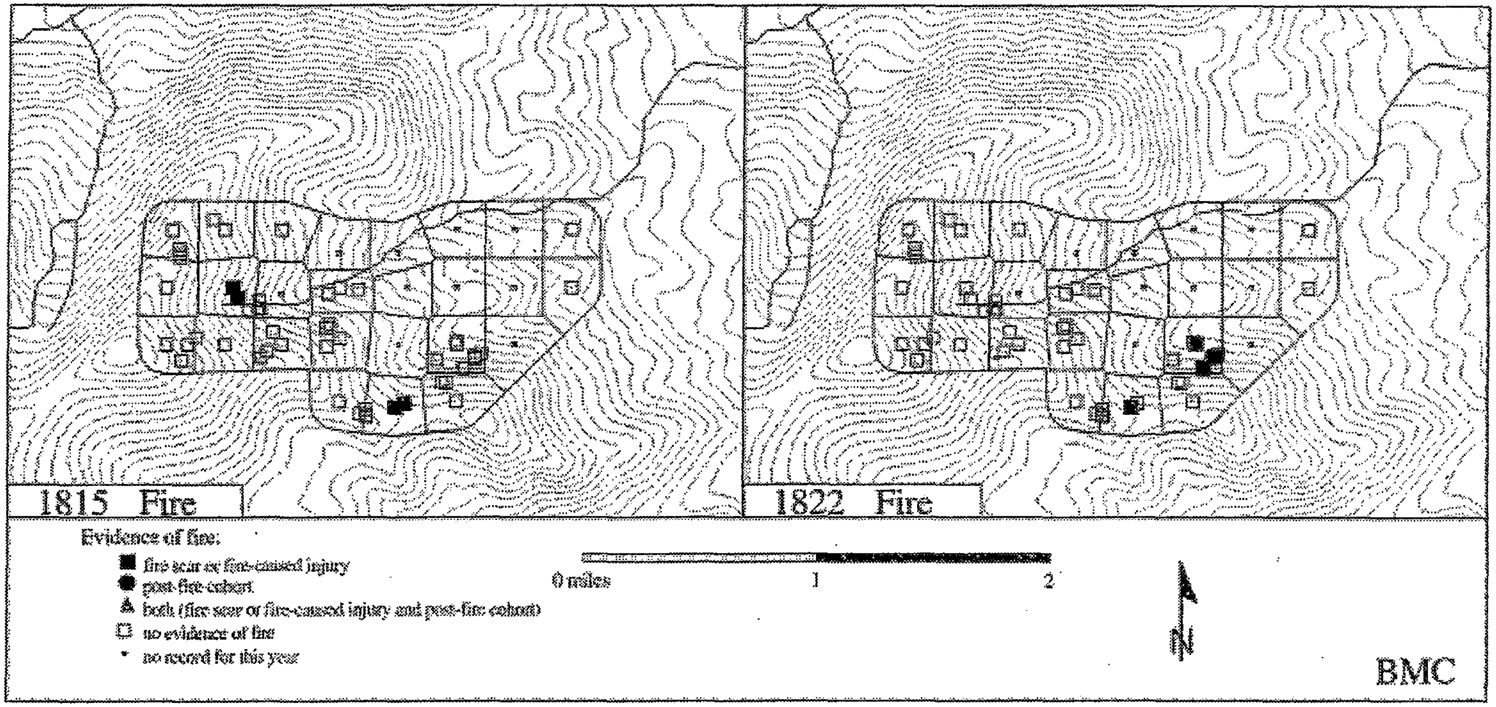
2
N
BMC

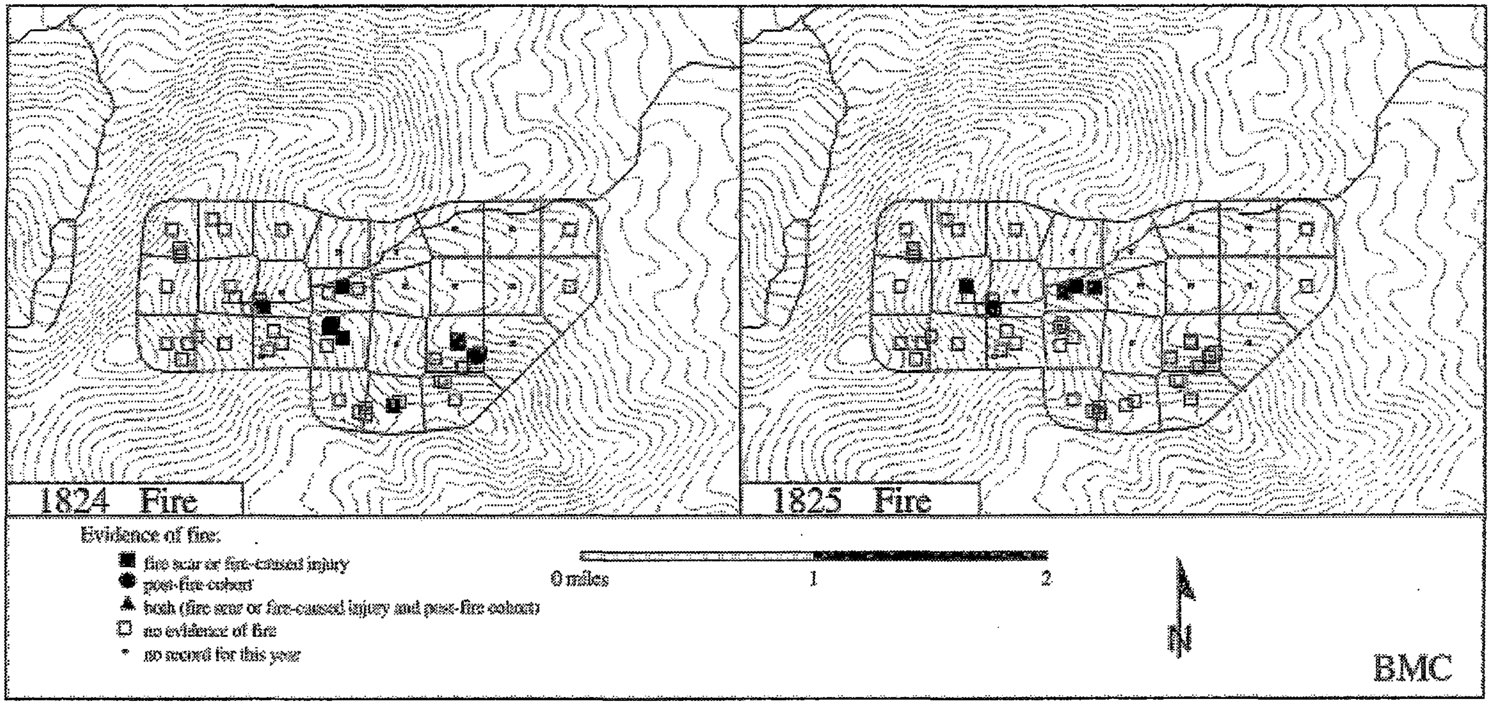

1771 Fire
1777 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC

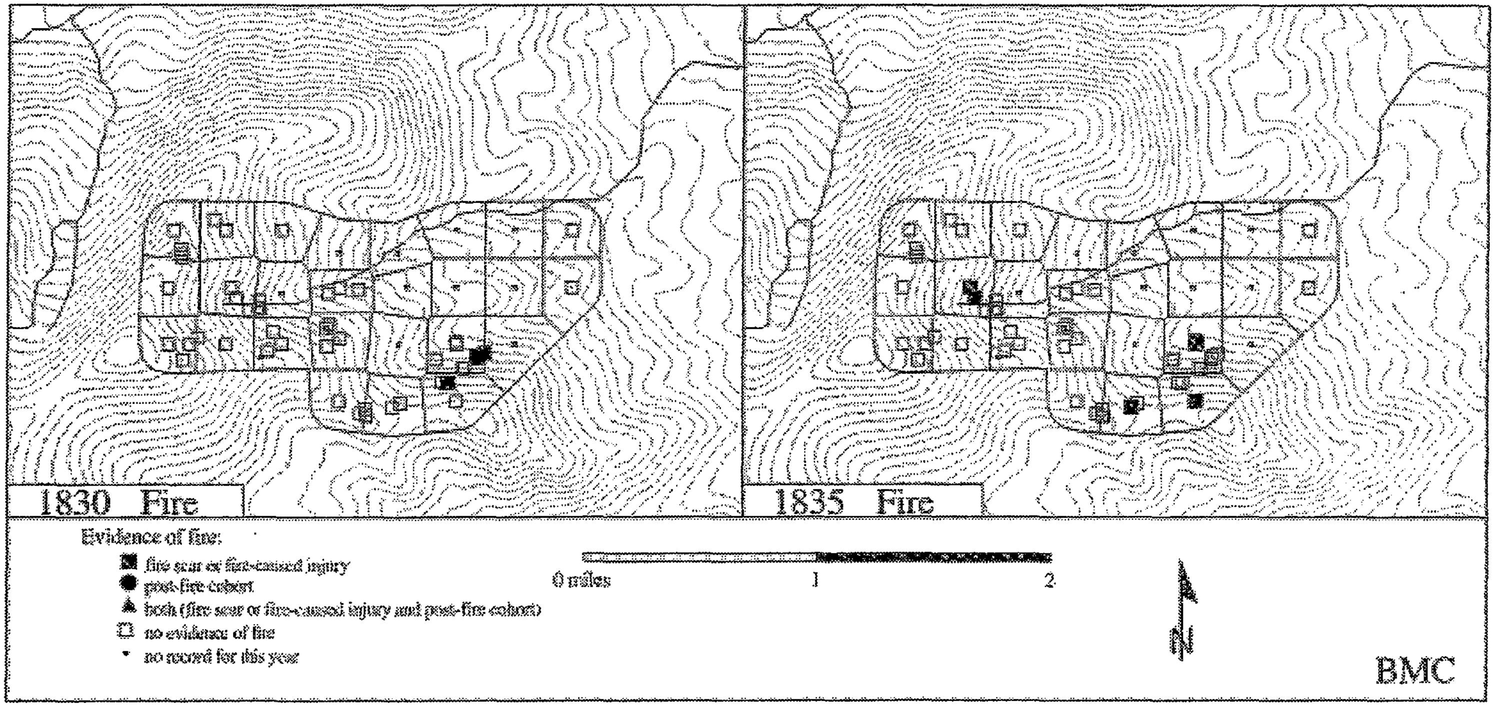

1780 Fire
1782 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC

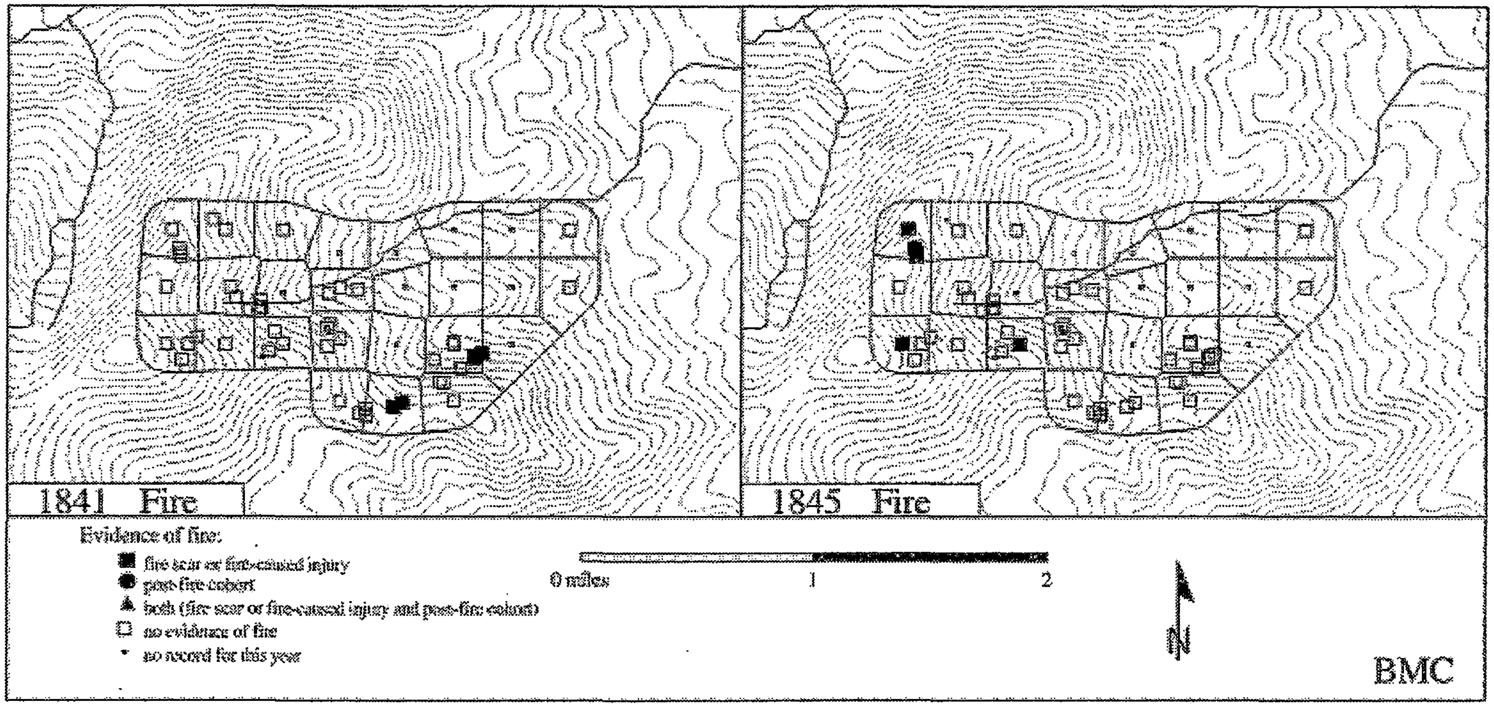

1794 Fire
1798 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC

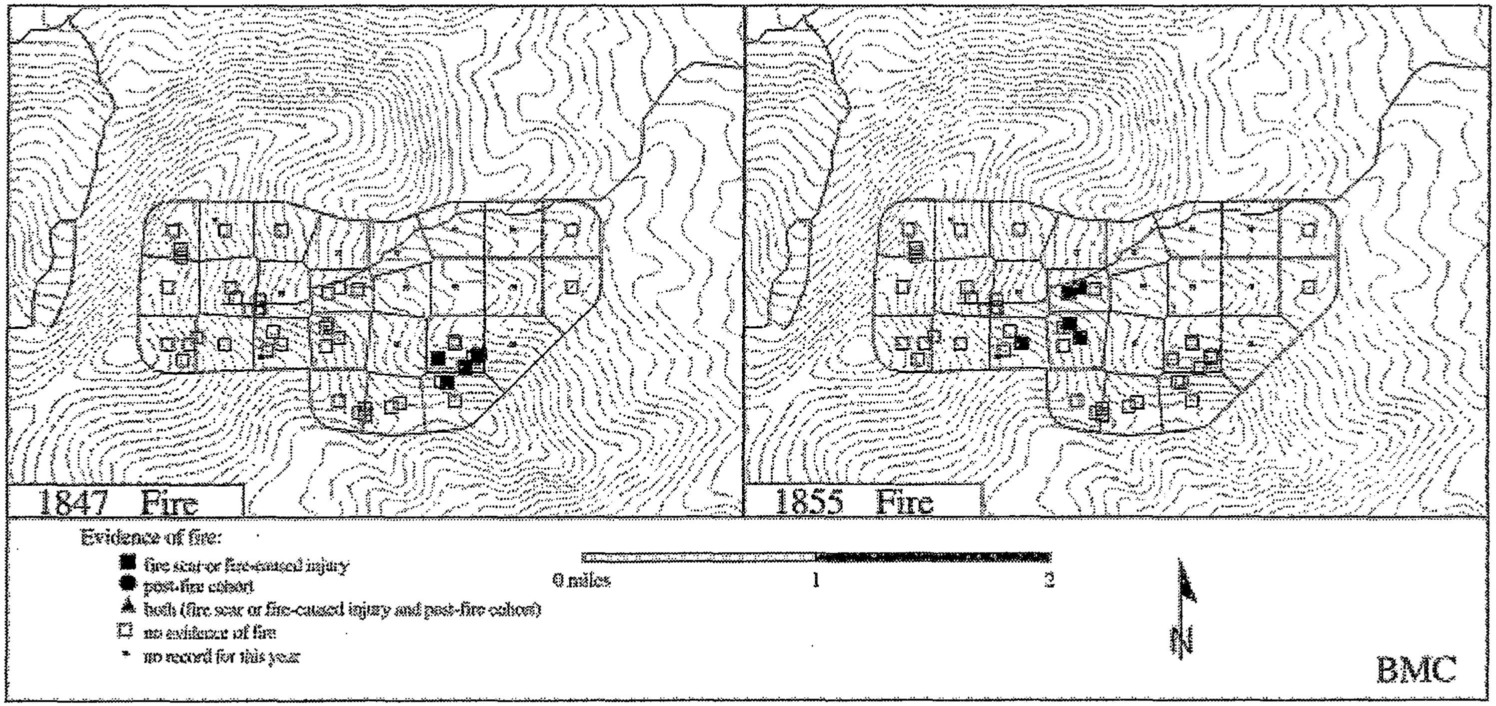

1804 Fire
1809 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC

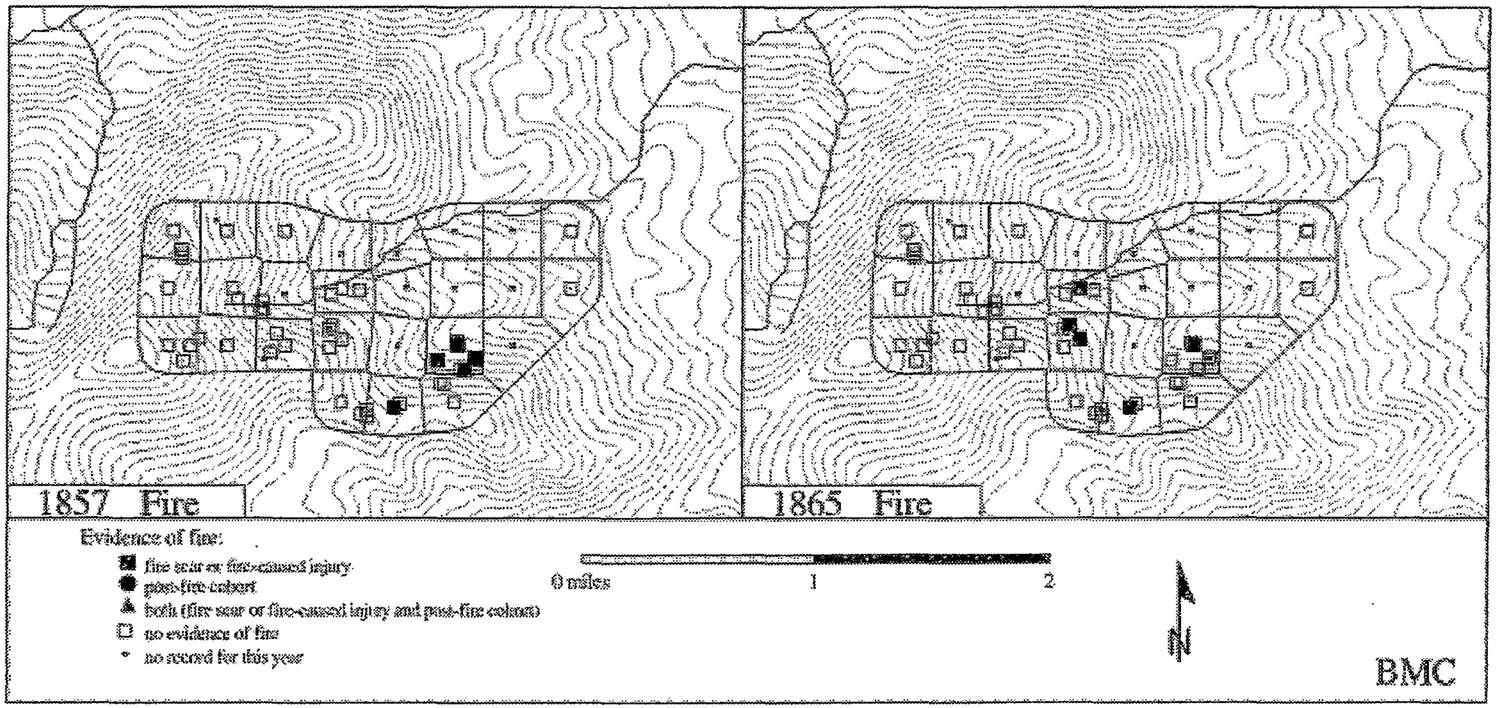

1815 Fire
1822 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC

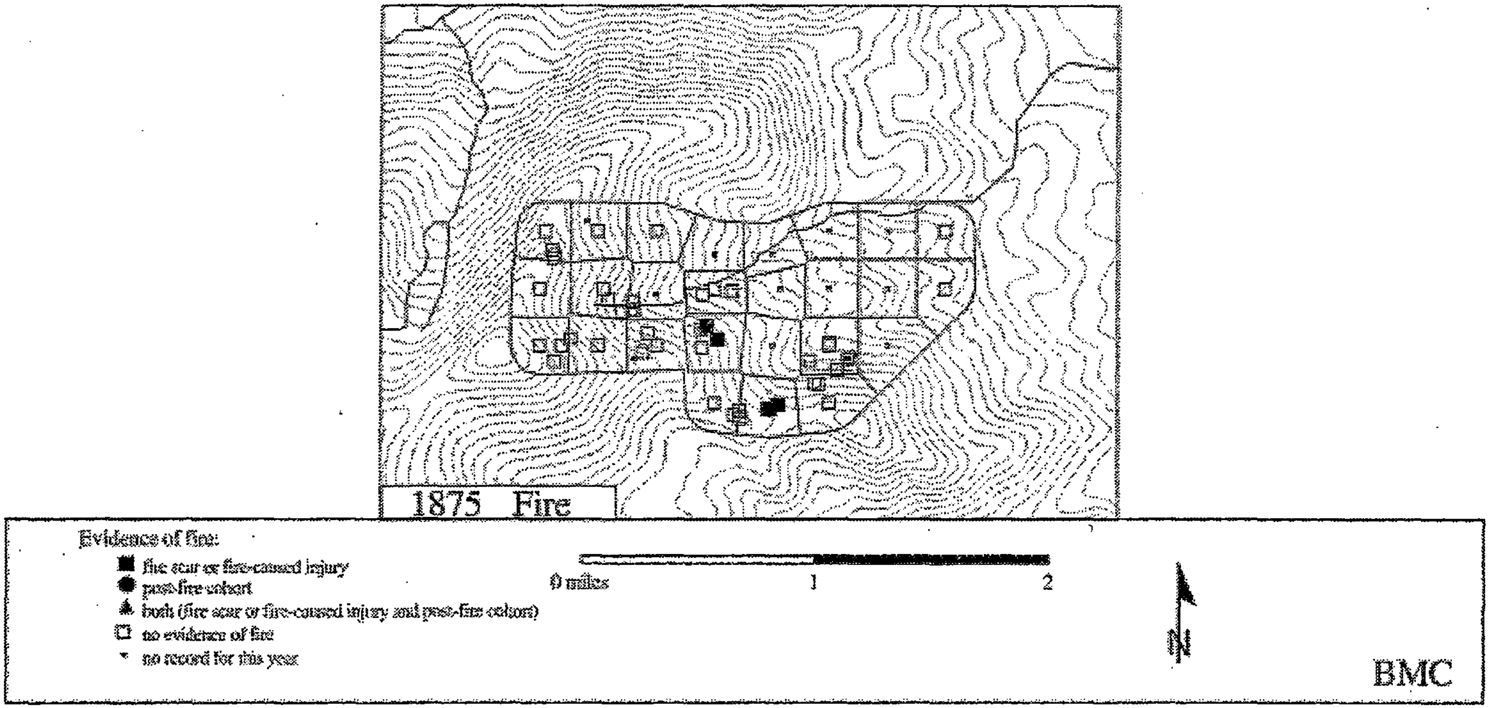

1824 Fire
1825 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC


1830 Fire
1835 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC


1841 Fire
1845 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC


1847 Fire
1855 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC


1857 Fire
1865 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC



1875 Fire
Evidence of fire:
fire scar or fire-caused injury
post-fire cohort
both (fire scar or fire-caused injury and post-fire cohort)
no evidence of fire
no record for this year
0 miles
1
2
N
BMC

DISCUSSION

This final report will be expanded and submitted for publication as a Forest Service general technical report (GTR), through the Rocky Mountain Research Station. This GTR will be our vehicle for disseminating the site-level summaries that we have included here, but will also include summaries of relative fire size, even-aged cohorts of trees and the raw data.

Our reconstructions of tree density are likely conservative. We are likely to have underestimated tree density in 1860 because some trees may have established before 1860 but died and were consumed by fire or rot since then. Note that our estimates of modern tree density are limited to trees that are >8 inches DBH. It is likely that the number of years to reach sampling height (≈8 inches) varied both within and among our sites.

Our understanding of the drivers of cohorts of early seral trees in ponderosa and mixed conifer forests is evolving rapidly (e.g., Brown and Wu 2005). These cohorts may result from a set of interacting factors that include climate, the timing of surface fires and moderate- and high-severity fires. We are currently identifying even-aged cohorts within and among our sites and will report on their presence and the factors that force them, in the GTR.

We have too little data, and all of it from targeted samples, to confidently report fire regimes parameters from Monroe Mountain or Old Woman Plateau. However, these fire-scar dates will be included in our analysis of the drivers of temporal variation in historical fire regimes in Utah.

ACKNOWLEDGEMENTS

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